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By-Products in Gas Manufacture.

[Lecture delivered by CHARLES E. MUNROE, Professor of Chemistry, George Washington University, at the Centenary Celebration, Franklin Institute, Philadelphia, Pa., April 19, 1912.]

In dealing with the interesting topic which has been assigned me in this Centennial Celebration it seems proper, and in the interest of clearness of treatment, to deal broadly with the subject of by-products before dealing with those of the gas industry. I have, but a short time ago, been called on to prepare an article on this subject for the "Loose Leaf Encyclopædia," and, with your permission, I will quote part of this article, since I feel that I have therein presented the matter to the best of my ability.

"By-products are substances or results obtained in the operation of a specific process, in addition to the substance or result primarily sought. In hunting game for food, the hides and feathers are by-products; in hunting game for hides or pelts, the carcasses are by-products; in manufacturing lumber, the sawdust and shavings are by-products; in brewing beer, the yeast is the by-product.

"In the classification of the products of manufacture, three groups are recognized—viz., *principal product*, which is that product of an establishment manufacturing more than a single product that has the largest total value; *subsidiary product*, which is a product of such an establishment having a less total value; and *by product*. A subsidiary product may be a utilized by-product, or it may be the product of an allied industry—as, for instance, bookbinding in a printing office, or compounding fertilizers in a cotton seed oil mill. This last example is one of many occurring in factories where the by-product of the principal industry—in this case cotton seed meal—becomes the raw material for the manufacture of a subsidiary product. The development and growth of manufactories using manufactured products as the raw material for further manufacture have not infrequently created such a change in the demand for the products of the primary establishment as to make one of its subsidiary products its primary product. A notable example of this is the Le Blanc process for the manufacture of soda products from common salt by the action upon it, in the first stage of manufacture, of sulpuhric acid. In this operation, hydrochloric acid gas is given off as a by-product. At first this was wasted by being allowed to escape into the atmosphere, where it produced most devastating effects. To avoid the nuisance thus created, this gas was collected by dissolving it in water, and sold, thus becoming a subsidiary product; but with a greatly increased demand for this substance, for the manufacture of bleaching powder and other uses, through which its value was enhanced, and with the competition of electrolytic and other processes, through which the cost of the production of sodas was reduced, hydrochloric acid became in many cases the principal product of the Le Blanc factories.

"As indicated by the examples cited, the custom of utilizing by-products is a very ancient one in its origin, though frequently in the newer countries, where the raw material was abundant, and in the early development of industries, where the unit of production was small and competition slight, the by-products have generally been wasted and frequently have become sources of nuisances. But, with the increase in density of the population, through which the necessity for abating the nuisances became urgent; with the increase in the unit of production; with a diminution in the quantity of the raw material, or the ease with which it could be obtained; and with the increase in competition, additional attention has been given to the utilization of the by-products of manufacture, until to day they have become of great importance in all industries, and of such commercial value that the creation and maintenance of many establishments have been determined by the ability to utilize and dispose of the by-products of their processes.

"Naturally, the by-products that were first to be utilized were those which were most readily observed and whose uses were most obvious. The by-products which ran off in solution or passed away as gases, or forms of energy, such as heat, or those whose uses were remote or less readily apparent, have until very recent times been allowed to go to waste. The discovery of the first of the aniline coloring matters, mauve, in 1856, by the English chemist, William Henry Perkin, and the fact that the aniline from which it is manufactured could be obtained in abundance from coal tar, gave an impetus to the utilization of the last enumerated by-product; and the rapid growth in commercial importance of the coal tar products industry so concentrated attention on this phase of manufacture that the utilization of by-products has gone on with increasing expansion ever since."

There exists a rather widely extended popular belief that the "coal tar colors" many perfumes, flavors and synthetic drugs, and numerous other substances, are by-products of the gas industry, but such is not the case for they are produced by the further manufacture of the by-products of this industry. This view limits the scope of my topic, which is, however, broadened by the modern view of the gas industry in that it embraces in its consideration not only coal gas, but all gases manufactured for the generation of light, heat or power and which are distributed for use by public service organizations. All of the processes of manufacture employed in the production of these gases depend upon the chemical transformation of the materials used, and in all processes other products beside the gas sought are yielded.

This is particularly true in the carbonization or, using the more precise chemical term, the thermolysis, of peat, wood, resin, coal, oils, and other organic bodies, in which these bodies are subjected to widely ranging degrees of temperature and quantities of heat when inclosed in containers, such as retorts, ovens, or kilns, which more or less completely prevent access of air to these bodies during the thermolyzation process, and which are so operated that the heat, which effects the thermolysis, is conveyed to them through the walls of the containing vessel. For these bodies are complexes. The simplest of them, such as the resins, produced from by-exudates from deciduous vegetation or the thermolyzation of such exudates, and the distillates of petroleum, are still complexes. They are not elementary. They are not even single chemical compounds, but they are aggregates of chemical compounds each of which is capable, under certain conditions of temperature and pressure, of undergoing a particular kind of decomposition with the production of certain particular products, each of which, were they to remain apart, might be of such a character as to form a useful product, but, being mixed, or associated with other products, the tendency is that these intermediate products of thermolysis react with one another, and that the final product, which may be, and usually is, a mixed product, is a final integration of the process as it has proceeded from its initial condition, through its manifold transformations, to its end condition.

The conditions described are those which especially obtain for coal, as known in England, or bituminous coal as it is styled in the United States. This is the substance which first met with general success and which is yet to-day largely used in the manufacture of gas. It is the substance from which coal gas, so styled, has been and still is, produced, and though commercially regarded as, and popularly believed to be, a definite and individual substance, it is not so; for it not only varies in its composition, constitution and characteristics as it is obtained from different localities, but it varies by degrees as it is obtained from different geological deposits in the same geographical locality, and may even vary in the deposits of the same geologic age, or, in technical parlance, of the same seam, according to the conditions to which it has been subjected. The vicissitudes to which coal forming materials are subjected in this conversion from cryptogamous vegetation, such as prevails in peat, or phenogamous vegetation in its many species, through lignite into coal, are admirably portrayed by Dr. T. E. Thorpe,[1] and the manifest complexity and variability of the product are there well indicated. The geological significance of these transformations of vegetation are set forth by J. D. Dana in that charming, yet accurate style, of which he was a master.

Notwithstanding the recognition of complexity we have known nothing definitely as to the constitution of coal or of the nature or amount of its components. A large number of ultimate analyses, showing the percentages of carbon, hydrogen, oxygen and nitrogen present in ash-free coal, have been made and recorded in literature, as have also many proximate analyses giving the percentages of moisture, volatiles, coke, or fixed carbon, and ash, with the sulphur and phosphorus contents. Such data has had and still has an economic value in gas making and coke making and in the utilization of the coal, or some of its products, in iron smelting or steel working, but it still leaves us uninformed as to what there is in the different varieties of coal or in any given coal. And we are not much further enlightened by the interesting comparisons made by Pennock,[2] and others, of the character and composition of the tars yielded by different coals whose proximate compositions had been precisely determined, for these tars were the products of thermolysis, accompanied no doubt by metathetical changes also.

It has long been known that peat, lignite and bituminous coal, certainly, are affected by some solvents. In the early days of my professional career I devised a scheme for the classification of the coal producing substances, and the different varieties of coal, based on the character of the colors which they imparted to aqueous potassium hydro-oxide solutions in which the powdered material had been digested. There is some question in this case as to whether the extracted matter was identical with that in the coal or whether it had chemically reacted with the strongly alkaline reagent used. It is known, however, that we have many neutral liquids such as alcohol, benzene, ether, chloroform, acetone, carbon tetrachloride, carbon disulphide, pyridine, ligroin and other petroleum distillates, to mention but a few at command, which are solvents of organic substances, through which hydrocarbons and their derivatives which may be present in the coal can be extracted unchanged, while by the action of reagents of known behavior, such as nitric acid, chlorine, caustic alkalies in the molten condition and the like, derivatives of these organic substances, whose generic relationships are known, may be obtained, and thereby, through both direct and indirect methods of approach, the constitution be ascertained.

Records of the attempts made to solve this problem of the constitution of coal, by means such as described, with the results thus far obtained, have been assembled and critically reviewed in a masterly manner by Frank Wigglesworth Clarke, in his "Data of Geochemistry,"[1] and it can only be said that the results are most meager, largely because the extractives are usually tars, which require further treatment for separation and identification, by slow and tedious processes, and that the total yields are rarely large. It may be of interest to announce that the recently created U. S. Bureau of Mines has taken up this problem as one of its studies, looking to a more complete and economic utilization of our coal, and, therefore, to the conservation of our fuel resources, and that the results of the preliminary investigations on these lines, by J. C. W. Frazer and E. J. Hoffman, of that Bureau, have been prepared for publication. I feel assured that, as more definite information is acquired, the character of our distillation processes, such as are now used in gas and coke making, will be profoundly modified, and that the nature and yields of the by-products of the gas industry will be materially changed.

Taking the industry as it has been and now is, it may be noted that the by-products of the coal gas industry are coke, gas, carbon, tar, ammoniacal liquor and spent purifying material, either lime or oxide. In the water gas industry tar and purifying material, with a meager amount of ammoniacal liquor. In the oil gas industry, lampblack, tar and spent purifying material, for the new Lowe process, and "hydrocarbons" for the cracked and compressed oil gases. While in the acetylene gas industry, calcium hydroxide is practically the only product incidental to the reaction other than the acetylene.

From the outset the commercial and economic value of certain of the collateral products obtained from the chemical reactions which yield coal gas were recognized, and to such an extent that the original organization, whose parliamentary recognition we now celebrate as a significant event in the evolution of chemical industries, was styled the "Chartered Gas Light and Coke Company;" the production of coke, by the distillation process employed, apparently being regarded by Winsor and his associates as of equal, or nearly equal, industrial importance to that of coal gas. We know that in the last quarter century the relative economic importance of the gas and coke obtained from bituminous coal by distillation processes has been, and to-day still is, in many localities or under certain industrial conditions, reversed, and that where by-product coke ovens are employed, the coke is the principal product and coal gas is one of the subsidiary by-products. In by-product coke making, particularly where gas is supplied to public service corporations for distribution, as is often the case, the other by-products are substantially those of the coal gas industry.

I say "substantially" with intent, for they would be identical only by the most remote chance, since it is recognized that, using the same coal, the products obtained differ in quantity and character when thermolyzed in the same retort with variations in the rate, degree and method of heating them, and with the pressures put upon them, and that when the device employed, such as vertical or inclined retorts, or ovens of the many dimensions and forms known, is substituted for the horizontal retort of standard type, the conditions under which the thermolyses and metatheses take place are so varied that the products are materially varied both in composition and quantity, and this difference is emphasized when the material treated differs, as does coal from different localities, or even from the same locality, but from different parts of the vein.

1. Coal. Its History and Uses, Macmillan & Co., London, 1878.
2. J. D. Pennock, J. Am. Chem. Soc. 21, 690; 1899.

1. Bulletin 491 (3d ed.), U. S. Geological Survey, pp. 705-731; 1911.

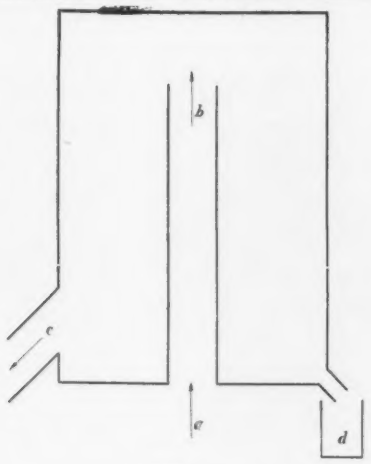
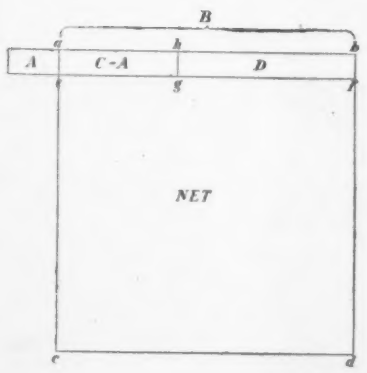


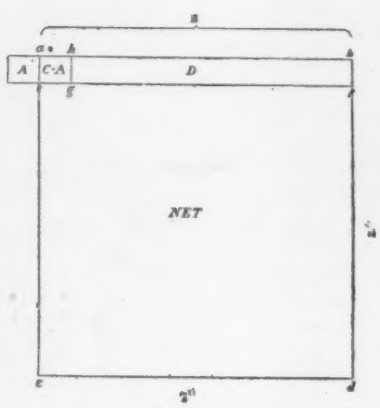
Fig. 1.



abdc	Total-T	600
efdc	Net-N	550
eghbdc	Gross-G	580
hbfg	D-	30
ahge	C-A-	20

Room	90°
Exhaust	95°
Humidity	50%
Air	12vols

Fig. 2a.



abdc Total-T	600
efdc Net-N	550
eghbdc Gross-G	595
hbfg D-	45
ahge C-A	5

Room	70°
Exhaust	75°
Humidity	50%
Air	6vols

Fig. 2b.

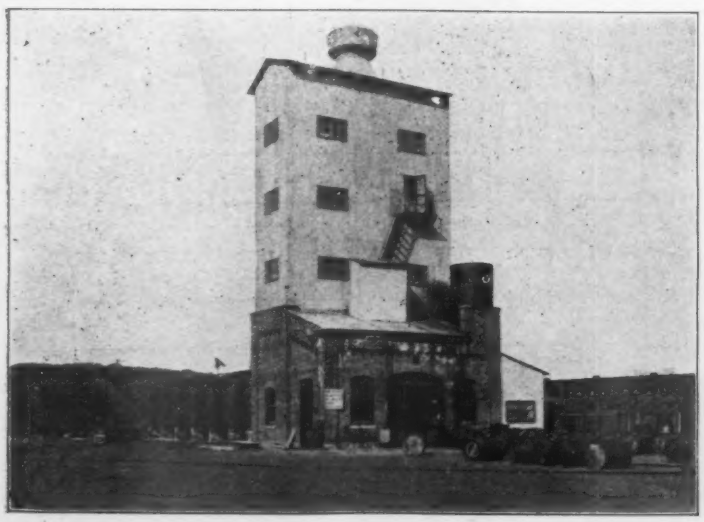


Fig. 3.

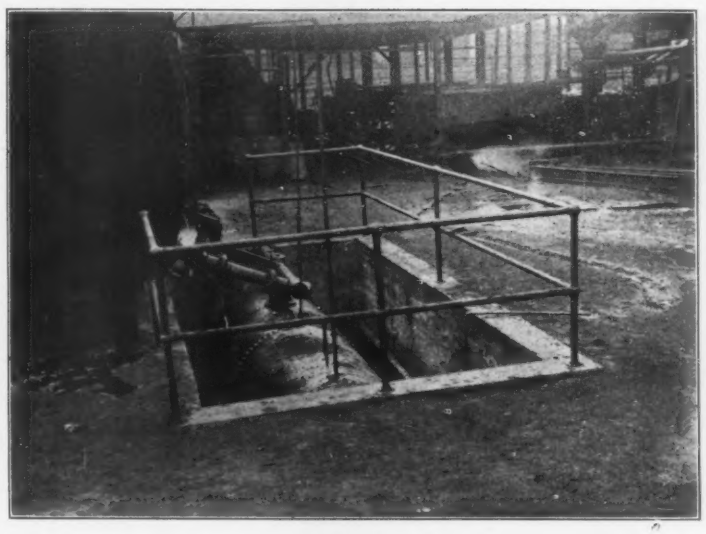


Fig. 4.

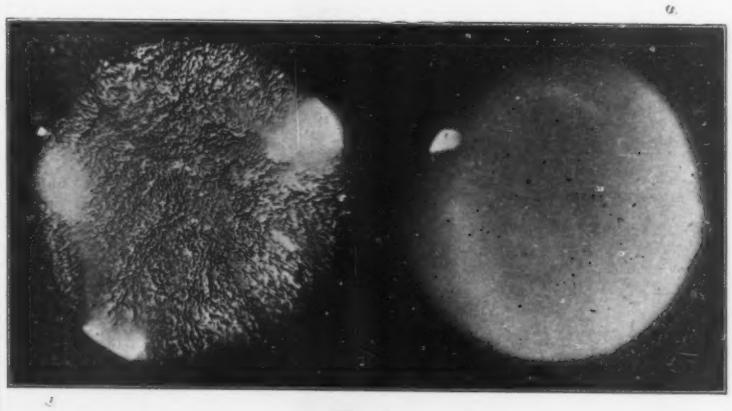


Fig. 5.

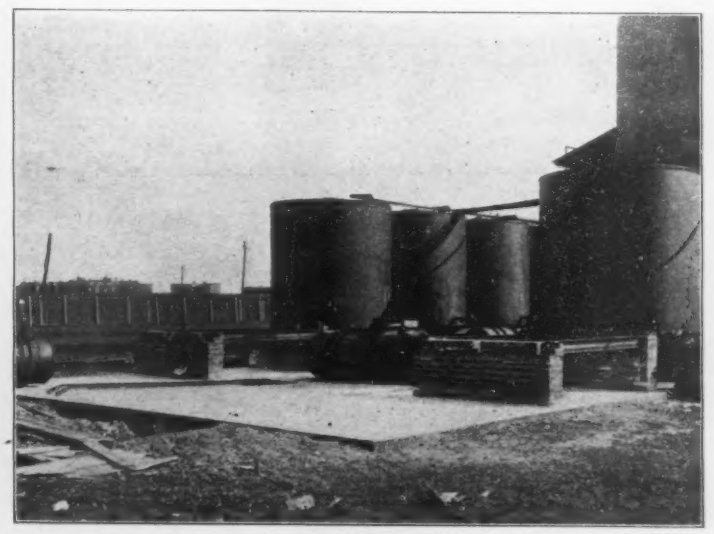
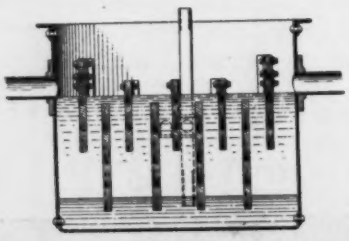


Fig. 5a.

Fig. 6.



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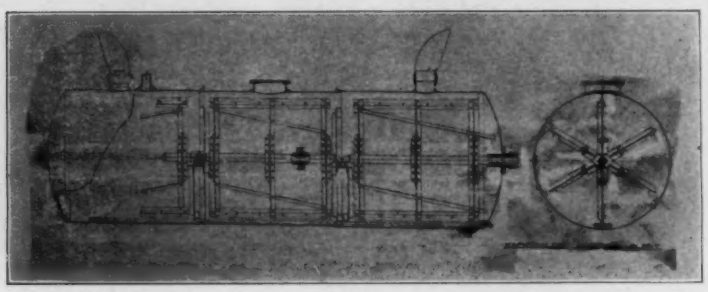


Fig. 8.

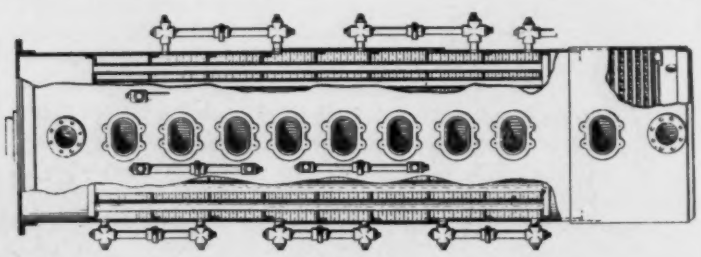


Fig. 9.

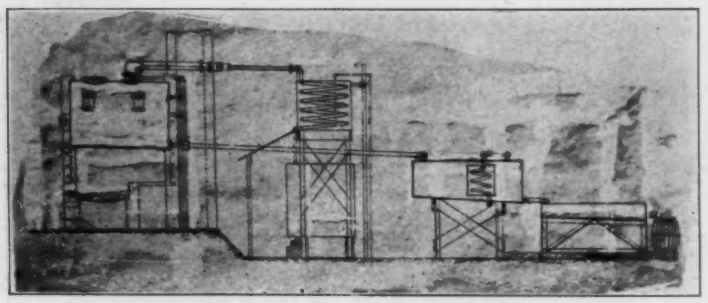


Fig. 10.

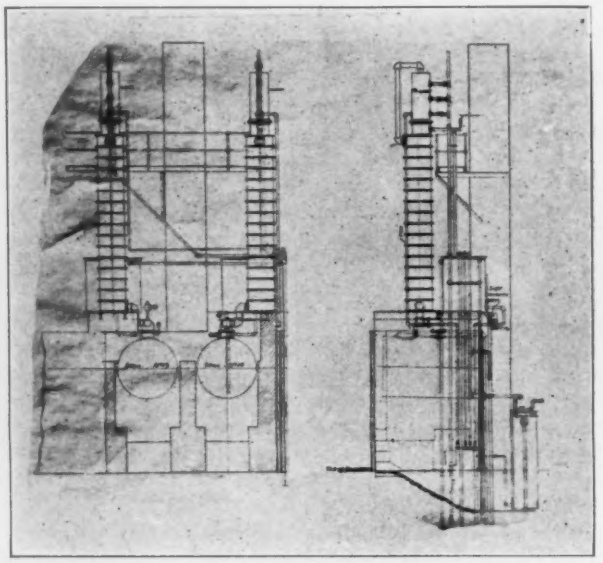


Fig. 11.

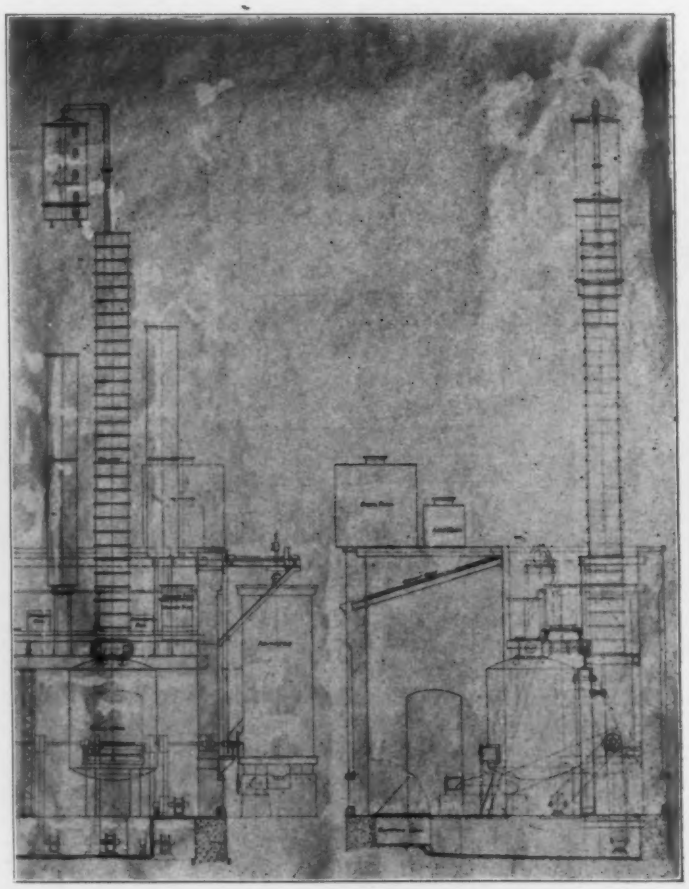
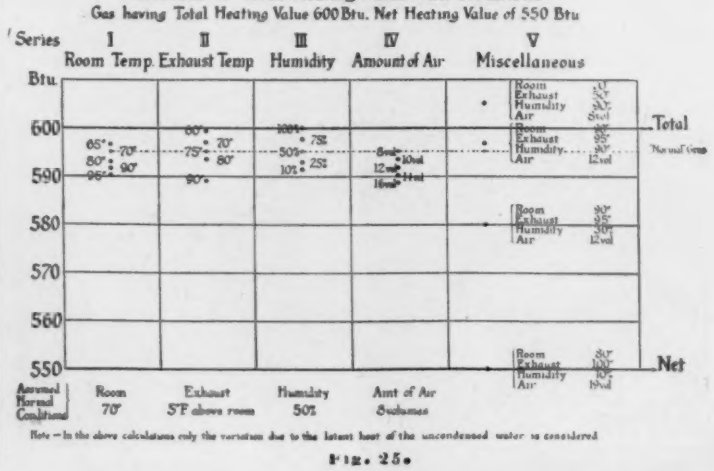


Fig. 12.



Note — In the above calculations only the variation due to the latent heat of the uncondensed water is considered

Fig. 25.

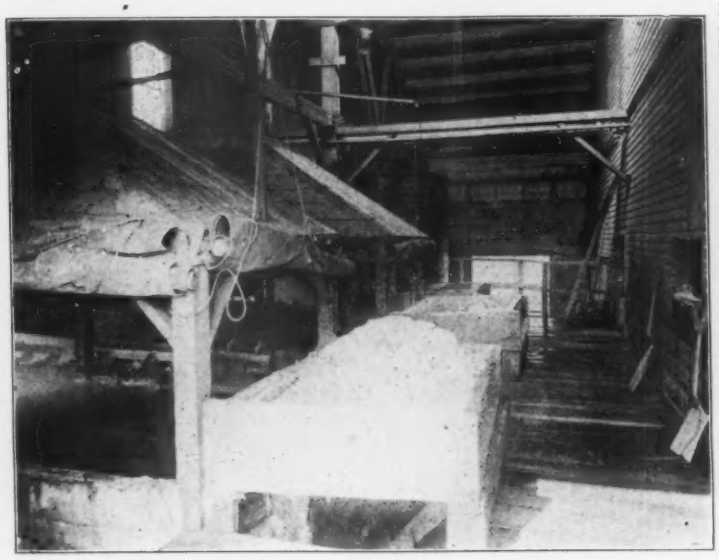


Fig. 13.

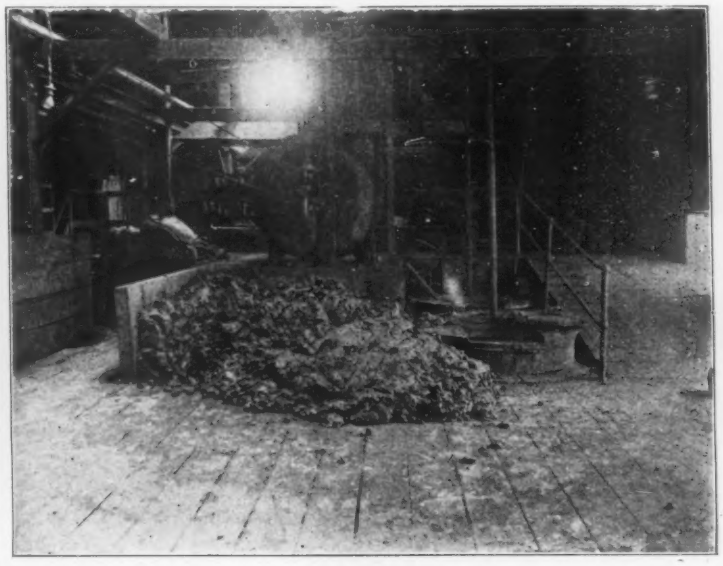


Fig. 16.

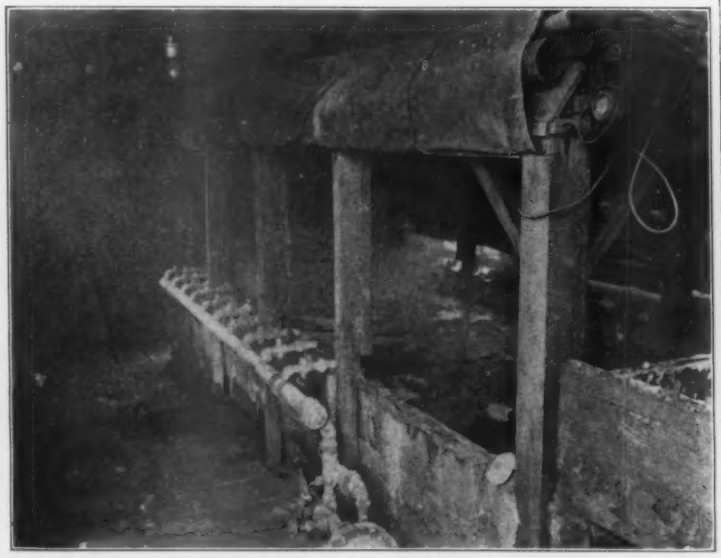


Fig. 14.

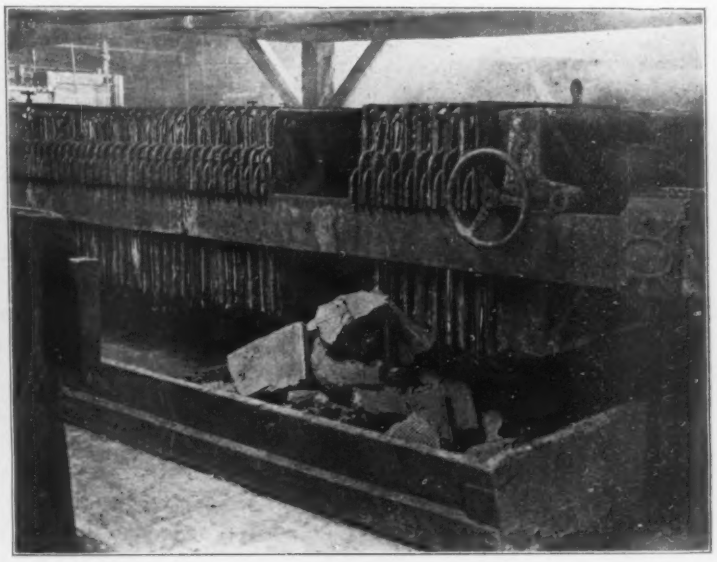


Fig. 17.

Fig. 15.

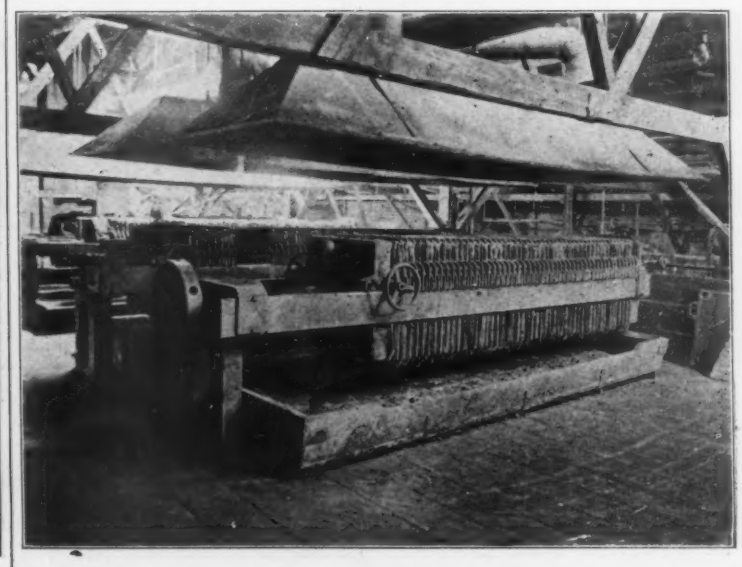


Fig. 18.

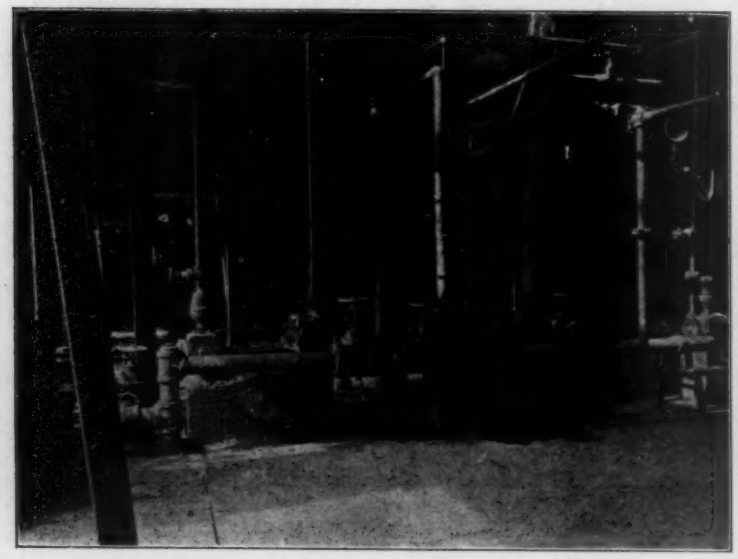


Fig 19.

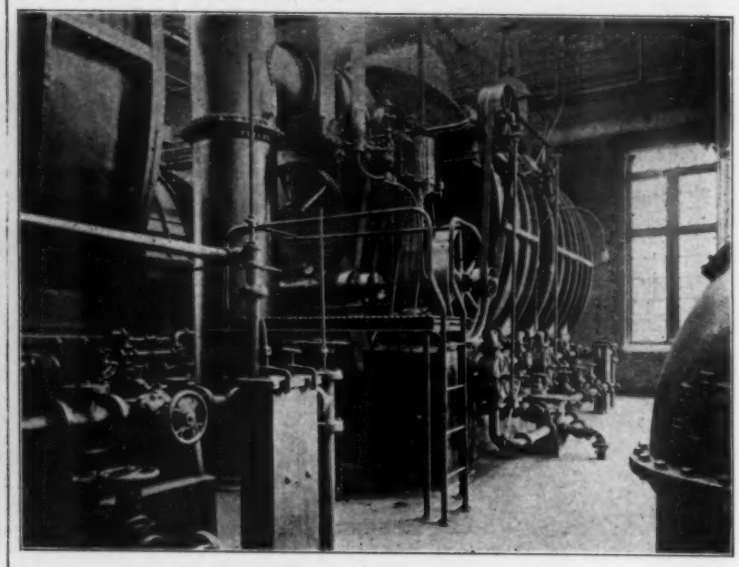


Fig. 22.

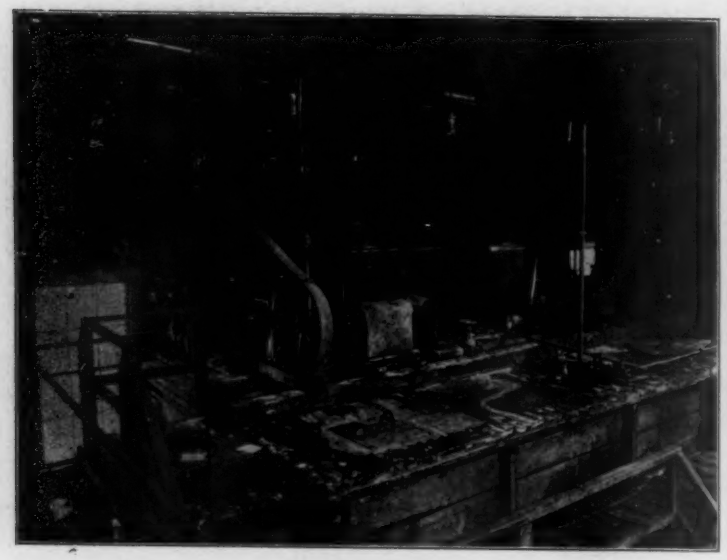


Fig. 20.

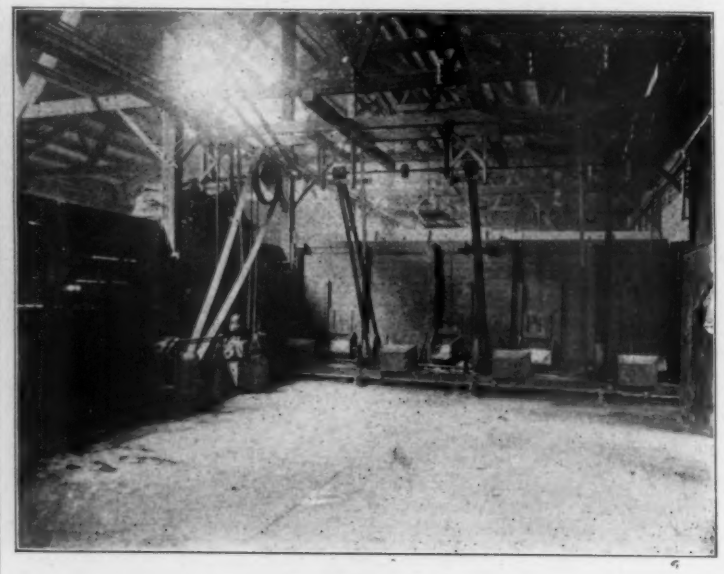


Fig. 23.

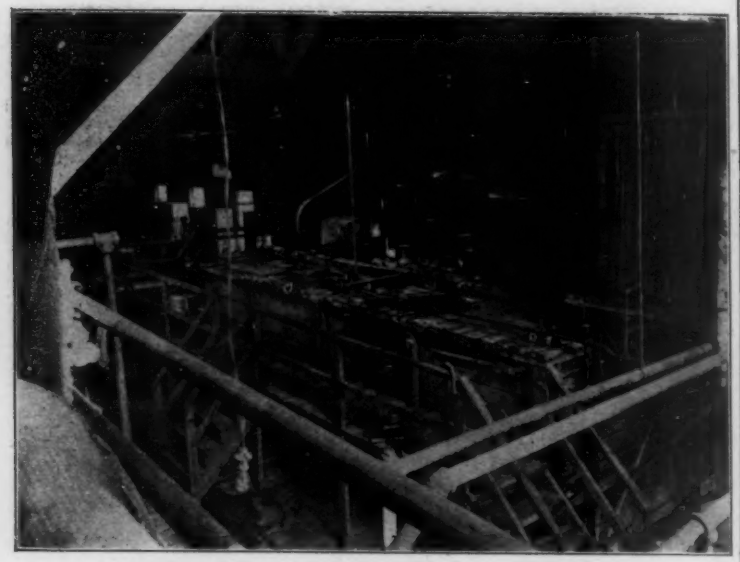


Fig. 21.

Fig. 24.

My presentation of the difficulties which beset the gas manufacturer in his endeavor to produce a gas of uniform character that will conform to the regulations or restrictions placed on him by the State or municipal regulation or ordinance with which he is environed, may perhaps have quickened your interest or stimulated your incredulity, if so this part of my thesis is completed.

But I call attention to the fact that complex and variable as the gaseous products of soft coal distillation are, the tar and ammoniacal liquor which are by-products are subject to as marked variations in yields or in composition or both, with differences in the coal used, and the processes or devices employed, and in their operation, as the gas is, and that these, but more particularly the tar, are the by-products which have lent special interest to the gas industry, and which in more recent years have proved important factors in its commercial success and in enabling this industry to maintain its place commercially in the presence of competing illuminants.

Of these by-products the ammoniacal liquor is chemically the simplest and yet it is complex and variable. It is produced from some of the nitrogen in the coal, and perhaps to a degree, when alkalies or alkaline earths are present from atmospheric nitrogen entering, or included in the chamber in which the destructive distillation of the coal is effected. Varying with the process employed and its operation, the ammonia content appears in the condensates as carbonate, sulphide or polysulphide, chloride, cyanide, sulphocyanide, and probably in other combinations, from which it is released, to a greater or less extent, by the action of stronger hydroxides, such as calcium hydroxide, in the process of recovery, when it is converted into the marketable forms of ammonia water or ammonium sulphate.

In the latter state of combination the nitrogen of the coal or the atmospheric nitrogen, which has entered into this state of combination, has become available for food for vegetation, whereas before it was not so. This forcibly illustrates the co-relation of country and city, of agriculture and manufacture, for while the coal remained unmined its nitrogen content was unavailable as plant food, but when that coal had been mined and employed in the manufacture of gas for city or town lighting, its nitrogen content was not only released from its inert condition of combustion, but brought into such association, through subsequent treatment, as to be available for plant food. To-day a larger part of the available nitrogen necessary for use in compounded fertilizers or for direct use in agriculture comes from the gas industry, or from its closely corelated industry, the by-product coke industry.

The utilization of ammonium sulphate from the gas industry in agriculture practically dates from the time of the governmental encouragement of the beet-root sugar industry in Germany. It is in this way corelated with the potash industry, which has been so recently a serious topic for diplomatic negotiations and which to-day remains a grave problem for governmental solution. Personally I find the available nitrogen question to be a wider one than that of agriculture. I find it to be closely concerned with the ability of a nation to protect and defend itself in a prolonged warfare. I find that in the immediate past and to-day the supposed dominant nations have been and are, through the necessity of available nitrogen in warfare, dependent nations, since they have sought for this available nitrogen the few sources of supply where it has been stored by nature's agencies, working in a comparatively simple manner. I have elsewhere suggested [1] that chemistry has in recent years released these nations from their state of dependency. It seems at first thought a far cry from the manufacture of gas, by which to extend the efficiency and efforts of the people of a nation, to its defense in time of attack, but chemistry has made this last relation relatively close, and the gas industry, if properly directed, may reasonably be expected to become a factor in the defense of the nation, and its managers may rightly feel that in wisely and justly directing the affairs of a gas company they are not only rendering public service but a patriotic service also.

In the development of the ammonia recovery from coal gas, a rather amusing and curious condition has developed. Originating as the gas industry did in England, this country has maintained its supremacy in the production of by-products, and, when ammonia and ammoniacal compounds from this source began to assume economic importance, there was devised in England a means for ascertaining the quantity of the valued component in a liquor by liberating it from its state of combination, through the aid of calcium hydroxide, and then measuring neutralization with a standard solution of sulphuric acid, which had been made up on the scale of Winchester gallons. This method of determining the ammonia content of liquors, known as "ounce-strength," was on its face obviously fair and equitable, and was shortly afterwards introduced into this country, but the difference in measures was overlooked, and the standard sulphuric acid was made up with the U. S. gallon as the measure, and ever since "ounce-strength" has had in the United States a different significance from that which it has had in England. Fortunately the content in real NH_3 or $(NH_4)_2SO_4$ is coming more commonly into use, and the discrepancy of statistics which had existed between different countries is being reconciled.

The vagaries of nitrogen in forming its various associations by which the many compounds of nitrogen found in the distillates from coal, from ammonia, and its multitude of substituted amines, to cyanogen with its numerous derivatives, result, is but one example of the multitude of complex changes and rearrangements of atoms and radical groups which occur during the process of gas making, where the apparently simple method of heating the coal is employed. For numerous as the nitrogen compounds formed may be, the known carbon compounds are many fold greater, since they include, not only the many representatives of various known homologous groups of acyclic and of cylic hydrocarbons, but also many of the oxy, sulpho and nitrogen derivatives of these hydrocarbons.

Attention has been called to the necessary variations in the composition and character of the gas which must result from the variations occurring in the composition and constitution of the coal used; the differences in the forms, proportions and character of the devices used in the carbonization of this coal, and particularly in the methods employed in the carrying out of the process, but the effects of these many differences are, if possible, more obvious in the tar which is one result, than in the gas, which is another result of the destructive distillation, and this fact is of prime importance for consideration by the gas works manager since tar stoppages are not infrequent sources of trouble in operation which may to an extent be remedied by so conducting the distillation process, in any system, as to obtain more liquid or less highly carbonized tars.

For it is well known and has long been known that in this distillation process heavy hydrocarbons or hydrocarbon derivatives of high boiling points, which have been evolved from the coal by heat, may condense defore reaching the hydraulic main and fall back upon the incandescent coal mass in the retort or upon the incandescent walls of the retort or other container, where they are cracked, depositing carbon, which appears on the walls as gas carbon, and yielding lighter and more volatile gaseous products, which again pass on to mix with the other gaseous products, but bearing with them some portion of the carbon. which has not been deposited, to foul the tar.

At the time that these splitting up processes are going on, or nearly simultaneously with them, building up processes may be taking place, for it is well known that under conditions such as obtain in gas retorts or in the gas making system in practical use, acetylene and acetylene homologues, such as meythl-acetylene, polymerize to benzene and benzene homologues, such as mesitylene, which may again be decomposed into simpler products at more elevated temperatures and which pass partly to the gas and partly, and more largely perhaps, to the tar.

It is this complex, vile looking, evil smelling, adhesive, by-product, tar, which was for long a stumbling block in the development of gas lighting. Early in the progress of the industry efforts were made to utilize it, but they proved of so little avail that when possible much of it was run off as a waste product into neighboring water courses destroying the fish, fouling the craft floating on the water and the structures bordering it, and giving rise to nuisances of a great variety of kinds. Among the unexpected results of this procedure I may recall that when in 1882, under orders from the Secretary of the Navy, I visited the Navy Yard at Brooklyn, N. Y., to investigate the cause of the corrosion of the copper sheathing of the newly fitted U. S. S. *Juniata*[1] and of other vessels which had been fitted with suits of copper at the Brooklyn yard, I found in the Wallabout considerable deposits of coal tar which had been rejected by the adjacent gas works in earlier days, and my experiments tended to show that this tar had played an important part in the corrosion which entailed considerable loss.

But this coal tar which was despised and rejected by man; which was a burden to the manufacturer and a nuisance to his neighbor, has, through the researches of the chemist, become a much valued and highly considered substance, and an aid to the gas industry, which it

1. The Nitrogen Question from the Military Standpoint; U. S. Naval Inst., Proc. 35, 715, 1903. Smithsonian Report for 1909, 225-236.

1 Proc. U. S. Naval Institute, 12, 391; 1883.

has helped to maintain and extend, ant through which the demands for cheaper gas has partly been met. Its history is filled with romance. The first English patent ever issued relative to the destructive distillation of coal was that dated August 19, 1681, and granted to J. J. Becher and Henry Serle "for a new way of making pitch and tar out of pit coal." At the outset tar was therefore to be classed as the principal product with gas and coke as by-products of the coal tar industry, but the industrial development took other courses and the order of importance was reversed until the gas makers were compelled to dispose of it at almost any hazard and in every possible way, and yet to-day through another change of industrial development this tar has become, perhaps, the most highly prized, or at least the most intellectually honored, of all the products resulting from the destructive distillation of coal.

It is here that the real romance begins when studied by methods, such as those spoken of earlier in this paper as promising man information relative to the constitution of coal, and when by additional methods this blackish, viscous, forbidding appearing tar was examined, it was found to be a storehouse of most interesting materials; and it has been found to be a storehouse of most fascinating possibilities and realizations.

It has been asserted that all foul smelling substances are compositions of matter and it is a fact that carbon disulphide which, notoriously, has long been condemned for its disgusting odor appears as a sweet, etheral smelling compound when separated from its associates by the methods of purification devised by the chemists. Likewise it has been suggested that offensive looking bodies are composites. Whatever may be true of this theory in its general application it is certain that coal tar, which in common with wood, water gas, petroleum, cotton-seed oil and other tars, of organic origin, is offensive in appearance and odor, is a product of the distillation of organic substances, and that all of these distillates are composites, and that when each of the chemically individual components of these compositions is separated from the composite mixture it appears in an agreeable condition to mankind as regards odor, or color, or as tried by other physical characteristics through which substances are differentiated or distinguished. For from coal tar there has been obtained the water white or colorless benzene and its equally colorless homologues which possesses such pleasant odors and which give rise to compounds of such markedly pleasant odors that the series of hydrocarbons of which benzene is the initial member has been long since styled the aromatic series.

This is but the beginning of the enumeration of the hydrocarbons present in coal tar, for besides the benzene series there was found present many of the conjugated derivatives of benzene, such as naphthalene, fluorene, phenanthrene, authracene, and many others; moreover there has been found present besides ammonia, nitrogen, containing compounds, such as aniline, the pyrinine, the picolines, the quinolines and isoquinolines and many other nitrogen containing compounds; sulphur compounds, such as thiophene, and the derivative thiophenes; and hydroxy compounds such as the phenols, and the cresols. This review embraces but a limited number of the numerous compounds which go to make up the material styled coal tar. The number with amount of each varies with the source from which the tar is obtained and the manner and means by which it is produced.

No one of these separate chemical substances is to be regarded as a by-product of the gas industry, for they are usually isolated from the coal tar in other establishments than gas manufacturing establishments. They are spoken of here only that we may note the effect and influence of the gas industry on other industries, and in doing so it may be proper to recall that the substances enumerated as occurring in coal tar are not only used by themselves to produce certain useful and beneficial effects, but they are more largely employed as the raw materials for further manufacture, and that from them we obtain not only compositions of matter such as cleansing compound, paints, paint removers, and the like, but also many chemical compounds having most valuable properties. It is from these isolated components of coal tar that we now produce the many coloring matters, a large part of which are used as dyestuffs, such as the aniline colors, the synthetic alizarine, which has driven the natural madder dyes from the market and which has opened the area formerly devoted to the growth of the madder root to the cultivation of food crop, and synthetic indigo which is rapidly displacing the indigo produced from natural sources. Antiseptics and germicides such as carbolic acid and the napthols. Explesives such as picric acid and the trinitrotoluene, known as tyotyl. Favoring materials such as the methyl salicylate and vanilline. Perfumes such as geranoil and artificial musk. Febrifuges such as antipyrine, acetanilid and many other synthetic remedies. Sweeting principles such as saccharin, and photographic developers such as hydroquinone.

Numerous as the bodies mentioned are, they form but a very small part of the many substances which have been or may be derived from coal tar in its further manufacture, nor do they begin to exhaust the beneficent results which have followed this chemical utilization of what was formarly a wasted by-product, for the coal tar dye industry has conferred a benefit of incalculable value upon bacteriology and upon all mankind by furnishing dyes which, when applied to microscopic preparations, make it possible to distinguish and recognize the germs of typhoid, cholera, tuberculosis, and other diseases; it is alleged that the industry was the principal cause of the establishment in Germany in 1877 of the imperial patent office; it is certain that the study of the constituents of coal tar and of their derivatives has created an almost new chemistry which development was largely facilitated by the ingenious speculations of August Kekulé regarding the constitution of the benzene ring advanced by him in a masterly treatise in 1865. Largely because of the insight which this theory of Kekule's gave man regarding the constitution of benzene and the possibility of obtaining from it, and its homologues, many of the chemical compounds already known and desired and many others indicated but not previously known, an enormous industry was created which within 40 years from the promulgation of the theory employed more than 15,000 workmen in Germany alone, producing products of a commercial value reaching to tens of millions of dollars and advancing the industry of mankind in a multitude of ways.

While coal gas tar has for more than a half century played a most important part in the chemical development of many countries, water gas tar which has been produced, particularly in this country, in very large quantities, has until recently been an unutilized by-product except in so far as it has been used for fuel, when mixed with breeze, under the retorts of boilers or as a source of power, in internal combustion engines, such as the Diesel engine, but through the investigation directed by Mr. W. H. Gartley, this material of which we have a most abundant supply has recently been made to yield its valuable components for use in further manufacture.

Water gas tar is a very complex mixture of a great many hydrocarbons. The principal commercial hydrocarbons are probably as follows: Benzol, toluol, xylol, naphthaline, methylanthracene, phenanthrene, and probably in the pitch, chyrsene and pycene. Water gas tar is formed in the carburetter and apparatus by the contact of the oily vapors, used in carburetting with the highly heated checkerbrick. Its formation differs from that of coal tar, in that the temperature which obtains is moderate and is very exactly regulated and the time of contact is short and uniform, and furthermore, there is a high percentage of hydrogen present at the start due to the water gas which is to be carburetted. The free carbon, therefore, in water gas tar is very low compared with that in coal gas, and its composition is generally more uniform. The oil used for enriching carburetted water gas varies in character from the paraffine base oils of Pennsylvania and Ohio to the asphaltic base oils of Texas and California. The presence of the hydrogen in water gas as affecting the formation of the tar is shown by the increased amount of olefines and the smaller amount of tar formed, which is more complex in its nature in the case of water gas tar than the tar formed by simple decomposition of the oil.

The general differences between water gas tar and coal tar are that water gas tar has a very low free carbon content; corresponding fractions have a slightly lower gravity; a larger fixed carbon content; absence of oxygenated compounds and a general increase in methylated derivatives, especially in the higher hydrocarbons, this confirming, in general, Shulze's theory of pyrocondensations at lower temperatures. Water gas tar varies in character somewhat according to the original character of the oil and to the method of operation of the set particularly as regards the temperatures carried in the fixing vessels.

The water gas tar as it leaves the apparatus exists generally in the form of vapor. This is dropped out when the temperature of the gas is reduced in the wash-box, scrubbers and condensers, aad the last traces are removed in the P. & A. tar extractor. A considerable quantity of water is also condensed at the same time, and the mixture of oil and tar is separated by utilizing the differences in specific gravity. The crude tar thus separated still contains considerably amounts of water held in suspension. This is further separated be storage of the crude tar in large tanks, where in time the water separates out to such an extent that the tar will contain not over 1 or 2 per cent. of water.

The crude tar is distilled in a fire still; that is, one provided with direct fire, and is cut into a number of fractions such as light oil, creosoting oil and naphthaline oil. The residue in the still is worked up then, according to the temperature of the distillation, into road compounds and pitches. The naphthaline oil fraction is chilled, and the naphthaline separated out in centrifugal machines. The light oil is washed with sulphuric acid and soda, and redistilled in stills provided with dephlegmating columns into crude benzols, toluols, etc. These are further redistilled to obtain the pure products.

The relations between tars from various sources as tested in this research are set forth in the following tables:

Comparative Ultimate Composition of Coal and Oil and Coal Tar and Water Gas.

	Coal.	Coal Tar.	Oil.	Water Gas Tar.
Carbon	82.47	89.21	84.28	92.70
Hydrogen	6.01	4.95	13.46	6.13
Oxygen	6.81	4.23	1.41	.69
Nitrogen	1.88	1.05	.24	.11
Sulphur	2.83	.56	trace	.37
Heating value, B.T.U.'s	15,553	15,708	19,200	17,193

Comparative Distillations of Different Types of Tars.

	Horizontal.	Coke Oven.	Vertical.	Water Gas Tar.
Specific gravity at 25° C	1.2039	1.1696	1.1302	1.0679
Free carbon, cold CS_2	21.16 p. c.	9.36 p. c.	5.83 p. c.	.30 p.c.
Distillation, p.c. by weight—				
Start to 105°	0.4	1.0	0.1	1.1
105-170°	1.4	0.3	1.1	2.8
170-225°	10.8	10.0	13.9	9.0
225-270°	10.1	12.4	12.5	12.6
270-300°	4.4	4.3	4.9	10.6
300-360°	4.6	3.0	1.5	7.9
Above 360°	20.4	28.0	27.3	30.4
Coke	46.5	40.6	35.5	25.5

Comparative Distillations of Three Types of Materials.

	Asphaltic Oil.	Water Gas Tar.	Coal Tar.
Specific gravity	0.9177	1.1165	1.2090
Free carbon	0.22	0.90	19.80
Distillation—			

	Per Cent. by Wt.	Gravity.	Per Cent. by Wt.	Gravity.	Per Cent. by Wt.	Gravity.
Start 110°	0 32	0.9105	0.29	0.9550	0.52	0.9862
110-170°	0.75	0.8215	1.44	0.9637	3.06	1.0095
170 225°	6.25	0.8436	14.61	0.9900	13.39	1.0146
235-270°	23.51	0.9604	24.05	1.0188	12.78	1.0357
270-315°	48.00	0.8782	15.73	1.0422	10.57	1.0785
Residue	20.27	1.1471	43.31	1.2310	58.92	1.2850

The next table shows diagrammatically the products now commercially obtained from water gas tar.

It seems a far cry from the distillation of gas from coal to the extraction of gold from its ores and yet industries as different as these two are correlated. To explain, it may be recalled that nitrogen has been found in the coal and that it appears combined in the by-products in many different ways. Among them it is found in the gas, the tar, the ammoniacal liquor, and, after the gas is purified, in the purifying material, combined with carbon to form cyanogen and cyanogen compounds, such as the ammonium salts, the thiocyanates and others. And a large part of the metallic gold now extracted from low grade gold ores and tailings is, following the process devised by MacArthur and Forrest and modified by many others, dissolved out by aqueous solutions of the alkali cyanides which can be operated so economically that in certain localities ores containing so small a gold content as $1 per ton can be worked to profit.

There have been many methods of cyanide recovery devised. These are described by Robine and Lenglen.[1] Among them is the Bueb process used to some extent in this country which consists briefly in scrubbing the gas, before its ammonia and sulphide are removed, with a solution of copperas whereby ammonium sulphate which remains in solution, and ferrous sulphide, which remains in suspension, are produced. The hydrogen cyanide and free ammonia in the gas now react withe ferrous sulphide giving ammonium ferrous ferrocyanide of the formula $(NH_4)_2Fe\,Fe(CN)_6$. Some of this double ferrocyanide may be converted into soluble ammonium ferrocyanide by the reagents present and to prevent this the "mud" is either boiled or made slightly acid with sulphuric acid.

In either case the insoluble double ferrocyanide is formed and the mud changes color from almost black to light yellow. The final products are an insoluble double ferrocyanide, and a solution of ammonium sulphate, which are separated from each other by filtration. The process has been found to work best at temperatures not exceeding 100° F. Under these conditions 90-100 per cent. of the total cyanogen is extracted. On a yield of 1¼ pounds of cyanogen per ton of coal carbonized, equivalent to about 110 grains of cyanogen per 100 cubic feet of gas, the amount of copperas required theoretically is 6.3 pounds and varies very little from this in practice. The ammonia absorbed in the process is equivalent to from 4-4.5 pounds of ammonium sulphate per ton of coal. About two-thirds of this appears as ammonium sulphate and one-third as insoluble ammonia in the press cake. The absorption of cyanogen by the Bueb method generally takes place in a standard washer. The gas should reach the washer freed from tar and at a temperature not over 100° F. The solution of copperas (ferrous sulphate) is run into the outlet end of the washer, where it is first converted into ferrous sulphide and ammonium sulphate. There is a tendency for the ferrous sulphide to adhere to and build up on the exposed surface. This would soon clog up the bundles in a standard washer, and for this reason the bundles in the last tray are replaced by large disks attached to the shaft and spaced about 3 inches apart. But even these gradually clog up and must be cleaned at times.

A device which kept the liquid in this chamber violently agitated would probably be preferable. In the original method of operating these washers the material was pumped forward from tray to tray whenever the first tray was saturated. This involved a great deal of pumping and it has been found that operating the washers on the same principle as an ammonia washer simplified the operation. The material in the inlet tray is tested from time to time by drawing off a small sample and acidifying with sulphuric acid. After stirring well a drop of this mud is put on a piece of white filter paper. Near it is put a drop of dilute ferric chloride solution so that the liquid from the two drops as they spread out on the paper will come together. A blue color occurring at the point where the drops meet is a sign that the mud contains an excess of ferrocyanide over iron and is therefore ready to be drawn off. If the material is saturated a slow stream of copperas solution is run into the outlet end of the washer. This forces the material in the different trays forward and the saturated acid overflows from the first tray. The copperas solution is kept running until the material in the first tray shows that it is no longer saturated.

In Germany the mud as it comes from the washers is generally sold to chemical works. At the Astoria plant of the Consolidated Gas Company, of New York, mud is pumped into lead lined tanks heated to about 200° F., and acidified with sulphuric acid.

The addition of acid changes the color of the mud to light yellow. During this operation large quantities of hydrogen sulphide are set free, in order that this does not escape into the room, the tanks are fitted with vent pipes connected to a fan which discharge the gases out of the building. Enough acid is used so that the material is slightly acid to litmus. The mud is again tested for soluble ferrocyanide with ferric chloride solution on a piece of white filter paper, and if the blue color appears ferrous sulphate solution is added a little at a time until upon tested the blue color no longer appears. This converts all the cyanogen into an insoluble form.

The mud now consists of insoluble double ferrocyanide of ammonia and iron and a solution of ammonium sulphate with a little ferrous sulphate and very little free acid. This is pumped into filter presses (Fig. 18). After the press is full, hot water is pumped through in order to wash as much as possible of the ammonium sulphate.

The wash water which is a very dilute solution of ammonium sulphate, is used for making up the copperas solution. It is very difficult to wash out the ammonium sulphate. The best results are obtained by finishing the pressing with mud made by stirring up some of the finished presscake with water until it disintegrates. The

1. Cyanide Industry. Trans by J. A. LeClere, with appx, by C. E. Munroe John Wiley & Sons, New York, 1905.

Water Gas Tar Products.

- Crude water gas tar
  - Light oil
    - Crude benzol
      - Refined 90 per cent. benzol
        - C. P. Benzol.
        - Refined special fraction.
        - C. P. Toluol.
      - Residue
    - Crude toluol
      - Refined com. toluol
        - Refined special fraction.
        - C. P. Toluol.
      - Residue
        - Refined solvent naphtha.
    - Crude solvent
      - Refined solvent naphtha
      - Residue
    - Crude heavy
      - Refined heavy naphtha
      - Residue
  - Naphthaline oil
    - Naphthaline salts
    - Dead oil
  - Dead oil
  - Creosoting oil
  - Road compound
  - Pitch

presses are about two-thirds filled with the neutralized mud from the washers and then finished with the mud made from the finished cake. In this way the gravity of the liquid coming from the presses is brought down to 8-10° Baumé to 1-2° before washing with water.

The solution of ammonium sulphate which runs from the filter presses is neutralized with ammonia. For this purpose some of the mud as it comes from the washers is boiled and the gases, principally ammonia and hydrogen sulphide, pass into the ammonium sulphate liquor from the presses. This not only neutralizes the free acid but also precipitates the small amount of iron present. This is necessary to avoid discoloration of the sulphate. The neutralized liquor is allowed to settle and the clear solution evaporated in lead lined pans. This solution contains approximately 1 pound of ammonium sulphate per gallon. The sulphate separates out on evaporation and is dried in a rotary drier (Fig. 24) by means of a current of air from a small blower heated by passing over steam radiators before passing through the drier. About 2.5 to 3 pounds of sulphate are produced per ton of coal carbonized.

The cyanogen cake from the filter presses has approximately the following composition:

	Per cent.
Water	50 to 40
Cyanogen	22 to 28
Ammonia	5.3 to 7

About 6 pounds of press cake are produced per ton of coal carbonized. When it first comes from the presses it is yellow in color, but contact with air it rapidly turns deep blue due to oxidation. It is sold to chemical works to be converted into sodium or potassium ferrocyanide. This is done by first distilling with lime which drives off the ammonia and forms calcium ferrocyanide. The solution of calcium ferrocyanide is filtered from the residue of iron hydrate and is then treated with sodium or potassium carbonate, forming the corresponding ferrocyanide and calcium carbonate which settles out. The clear solution is then concentrated and the ferrocyanide crystallized.

Through the courtesy of Mr. Walter R. Addicks I am able to exhibit the following pictures of the cyanide recovery apparatus used in a gas works in this country:

No. 13—Shows tops of underground copperas mixing tanks with motor driven stirrers; copperas bins at the rear. Copperas solution is forced over to the cyanogen washers by steam pump on the left.

No. 14—Shows cyanogen washer which receives the copperas solution from tanks shown in No. 13. After copperas solution has extracted the CN from the gas it is returned to the factory in the form of cyanogen mud and stored in underground tanks under filter press platform until ready to be worked up.

Nos. 15 and 16—Top of neutralizing tanks where the cyanogen mud is neutralized with sulphuric acid.

No. 17—Shows two of the high pressure pumps which pump the mud from neutralizing tanks through the filter presses.

No. 18—Shows filter press closed ready for filling.

No. 19—Shows filter press open, and partly dumped; the press-cake is visible in the foreground.

No. 20—Shows pile of press-cake.

No. 21—Shows cyanogen press-cake bagged, ready for shipment.

No. 22—View of lead-lined evaporating pan for sulphate liquor. Note steam header to the left, which is connected to lead pipe coils in bottom of pan.

No. 23—Shows ends of sulphate evaporating pans with piles of sulphate crystals on drain-boards.

No. 24—Shows rotary sulphate dryer with pile of sulphate under discharge end to left, and bags of sulphate in the foreground.

Unfortnnately the demand for cyanides is not yet sufficiently large to warrant the cyanide recovery process being pushed very far.

Another by-product which warrants further consideration is the spent oxide. Material rich in sulphur has been burnt in acid chambers and it has been proposed for use in copperas making. Two sulphur recovery processes which have been demonstrated as feasible and operative in the laboratory are now being tested on a commercial scale in factories, Burkheiser's recovery process being operated in connection with the Flemalle Graude coke ovens near Liege, Belgium, while Walther Feld's rival process is being employed at the gas works in Konigsberg, Germany. Both aim to produce ammonium sulphate from the ammonium compounds in the gas liquor and the sulphate compounds obtained from the coal. Reid's process is of special interest to the theoretical chemist in that the formation of the commercial product sought and the saving of the useful matter accomplished is effected through the aid of the tetrathionates and the controlling under manufacturing conditions of the reactions through which they are formed and those into which they will enter.

It may, perhaps, be admissible for me in closing to refer to a scheme for gas making at the coal mine which has interested me much for a long time. I, perhaps, cannot beter present the matter than by quoting from an address made to the American Institute of Chemical Engineers in 1909.[1]

"I have long looked upon our present custom of transporting coal long distances to be converted into gas as uneconomic, for a not inconsiderable quantity of coal is burned to provide the energy with which to haul this coal. Not only that but, since the gas constitutes but a very small percentage by weight of the coal, there is a considerable waste in hauling the coke, with its ash and the by-products. Further, to provide for emergencies, large stocks of coal must be accumulated in advance at the gas works, and as coal, particularly gas coal, begins to deteriorate as soon as it is removed from the mine, there is a very considerable loss going on all the time from this cause. Further, as the by-products or residuals are now purchased in the crude state in relatively small quantities at the different gas works, a large part of their value is consumed in collecting and transporting them to central refineries.

"By producing the gas at the mine and shipping it by pipe line the cost of haulage in the coke, with its ash, and crude by-products is saved. The wastage of coal by weathering is saved. The cost of collection and transportation of the crude residuals is saved. Such coke as is not needed for industrial purposes can be converted in producers into gas which, by means of internal-combustion engines, can be used in generating electricity for distribution, and the ash from this coal can be put into the mine for use as a filler in place of coal.

"It is evident that gas can, under these circumstances be made, and delivered at a much less cost than is the case at present, though it may be necessary after long travel to enrich it near the point of consumption. Furthermore the valuable areas occupied by gas plants in our cities can be given up to more concentrated industries and cheap country lands be substituted for them."

The pertinency of this proposed scheme to the topic given me for consideration lies in the improved opportunity which this plan would afford for the utilization of the by-products and I foresee should this plan of gas generation at the mine ever be realized there would grow up about the gas generating plant a large number of industries based upon the utilization and further manufacture of by-products, and that they would be greatly fostered, as would many other industries, by the very cheap gas, which could, under these circumstances, be produced for use as a source of heat, power or light, and which could be so cheaply produced as to enter, on the spot, into competition with water power as a source of electric energy. It is of interest to note that Sir William Ramsey has recently given this suggestion of carrying on the manufacture of gas at the coal mine his endorsement.

[Continued from Page 362.]

PROCEEDINGS OF THE EIGHTH ANNUAL MEETING, ILLINOIS GAS ASSOCIATION.

Held in the Auditorium Hotel, Chicago, March 20 and 21, 1912.

First Day—Morning Session.

The President introduced Mr. C. J. Bacon, who read the following paper on

SOME METHODS OF COKE DUST DISPOSAL.

One of the serious problems with coke manufacturers and consumers is the economical disposal of refuse dust. Although it is more vital to the coke ovens where a comparatively large quantity of low heat value is unavoidably produced in the process of manufacture, nevertheless the same problem, in a minor degree, confronts the consumer who finds on his hands an accumulation of small coke broken from the large sizes in handling. The contents of this paper are from investigations and tests conducted for the purpose of determining the relative economy of several methods of disposing of a yearly production of approximately 50,000 tons of dust, as well as an accumulated stock of 100,000 tons from by-product coke ovens. It is hoped that the data, discussions and conclusions herein presented are broad enough to be of assistance in other lines of the coke industry.

This waste of coke at the ovens is due mainly to the smaller pieces being loosened and broken off by abrasion, and a crashing effect in the various operations of pushing the charge from the ovens preparatory to quenching, of transferring to screens and of the screening operation itself. Doubtless the results vary somewhat with the methods employed, but as the province of this paper is in dealing with the disposal of the refuse, no further consideration need be given to the manner in which it is produced.

The material under consideration is the smaller of two sizes, separated in the rotary screens from the large size used in blast furnaces. The screenings are known as "breeze" and "dust," the former composed of sizes over ½ inch and through a 1-inch screen, while the latter is all material passing through a 1½-inch screen. The sizes are changed slightly from time-to-time, but this makes very little difference in the average size of dust, as screening tests have shown that only a very small portion is larger than ½ inch. As a rule, the breeze amounts to about 2 per cent. and the dust to about 4 per cent. of the total coke produced.

The breeze finds a field of usefulness in heaters for dwellings, etc., and, as the demand is considerable, no difficulty is had with the disposal to employees at a price commensurate with its value if used for power purposes; therefore, it does not require consideration.

The dust cannot be economically used in its natural state without special provision in the way of equipment and attention in either boilers or producers. There is no reason to expect success in burning dust in any ordinary type of gas producer, on account of abnormal amount of clinker, and the excessive pressure required for forcing air through the fuel bed. Mixtures with coal only modify the extent of these limitations. The nature of the difficulties is similar to that found in the boiler experiments described later.

Relative to the degree of success attained in burning bréeze under boilers, the tests, shown in detail in Appendix I., indicate in a general way that practically the same efficiency, overload cappacity and evaporation may be obtained with hand-fired coke breeze as with Illinois coal. These tests were made under steel mill conditions, where, on account of the limitations imposed by the class of labor and the fluctuation of steam demand, it is not practicable to operate boilers at extreme overloads. In the course of this investigation a number of schemes for the disposal of the dust were attacked:

1 Trans. Am. Inst. Chem. Eng., 2, 100. 1909.

(a) Attempts to burn it in natural form or mixed with coal in boilers without special equipment or methods.
(b) Use of special apparatus and methods as aids to successful burning in boilers.
(c) Briquetting process.
(d) Returning to ovens as part of the charge.

Another proposed method, not included in this investigation, but offering an alluring prospect of success, is gasification of the dust in a blast furnace type of producer, the distinguishing features of which consist of high blast pressure to force air through the column of dust, continuous gasification, fluxing and liquefaction of the ash. Experiments along this line have been made by the United States Bureau of Mines, showing that fluxing of the ash is easily accomplished.

Physical and Chemical Properties.—Since the economical realization of the heat value of the small sizes of coke, by direct application in boilers and similar furnaces, is seriously interferred with, if not prohibited, by the effect of the high ash content and fineness of the material, it is pertinent to consider the chemical and physical properties of the various sizes from by-product ovens. Although the briquetting process is a remedy for the detriment due to fineness, nevertheless, the presence of considerable quantities of ash interferes with the demand for such briquets.

The analyses of several representative samples are given in Table 1. The moisture content is independent of other properties. The B.T.U. value may be computed by taking the combustible at about 14,700 B.T.U. per pound.

The marked excess of volatile matter and ash in the dust over the large sized coke is obvious when the manner in which the dust is produced is considered. During the coking process the coal, in contact with the walls of the ovens, is likely to be over-coked, resulting in high ash content, while at the middle of the charge, where the heat is less intense, traces of partially coked coal are present. Moreover, cleavage of the charge is likely to take place where excessive quantities of slate are present. When the charge is pushed, and during all the subsequent handling operations the abrasion removes much of this mineral and votatile matter, thereby increasing the percentage thereof in the small sizes of coke.

TABLE 1.

Volatile Matter.	Fixed Carbon.	Ash.	B.T.U. Dry.	Moisture.
5.97	72.86	21.17	....	15.12
5.34	77.54	17.12	....	9.18
5.20	78.25	16.55	....	14.47
4.90	79.54	15.56	....	12.53
4.19	80.01	15.80	....	13.00
7.87	78.67	13.46	....	15.20
5.08	76.91	18.01	....	...
2.25	74.10	23.65	11,426	12.50
3.20	74.10	22.70	11,613	11.10
2.50	76.10	21.40	11,862	4.16
2.97	74.75	22.30	11.426	12.00
Avg.. 4.49	76.62	18.88	....	....

For comparison, the analysis of the regular output of furnace coke over 1-inch screen, may be stated as approximately:

Volatile matter..... 1.7 per cent.
Fixed carbon... ..... 89.2 "
Ash..... 9.1 "

While the breeze has a composition intermediate between the dust and full-sized coke, as shown by

TABLE 2.

Volatile Matter.	Fixed Carbon.	Ash.	B.T.U. Dry.	Moisture.
3.94	77.16	18.90	....	22.34
1.33	81.45	17.22	12,220	14.00
1.44	83.77	14.79	12,547	11.00
1.25	84.32	14.43	12,547	10.66
1.96	83.01	15.03	12,407	2.27
1.55	84.41	14.04	12,812	2.32
3.06	85.61	11.33	....	....
Avg.. 2.08	82.82	15.10	....	....

In regard to the relative proportions of different sizes composing the dust, as well as the percentages of ash in the respective sizes, the screening tests of representative samples show some interesting characteristics. The results are given in Table No. 3, and the averages are plotted in Fig. 1.

An examination of these results will show that by far the greatest proportion is larger than ¼ inch, while the respective amounts decrease with the size of screen, with the exception of the fine powder passing through the 100-wire screen. The ash tests indicate an increasing ash content with a decreasing size, which is to be expected, for the same reason that that the analyses of breeze and dust each shows higher percentages of ash than full sized coke; that is, the effect of abrasion in rubbing off the surfaces of the large pieces where the coking has been carried too far. These ash tests of dust indicate a peculiarity, in some instances, of high percentage of ash in the size remaining on No. 8 screen. This may be accounted for by the fact that the coal, previously to coking, is crushed to about ¼ inch, and any slate contained probably goes through the ovens unchanged, therefore showing up as ash in the coke dust of that size.

That high ash content is due to the presence of pieces composed largely or entirely of slate, was demonstrated by direct experiment. A pail was partially filled with coke dust and water was added until the coke was entirely covered. The coke dust was then stirred for a short time, followed by shaking the pail. The water was drawn off and samples taken at various levels. A small proportion of the coke floated on the water and some fine material was carried off in suspension. Samples of the settled material at the top, ⅓ down, and at the bottom of the pail were taken and analyzed for ash, as follows:

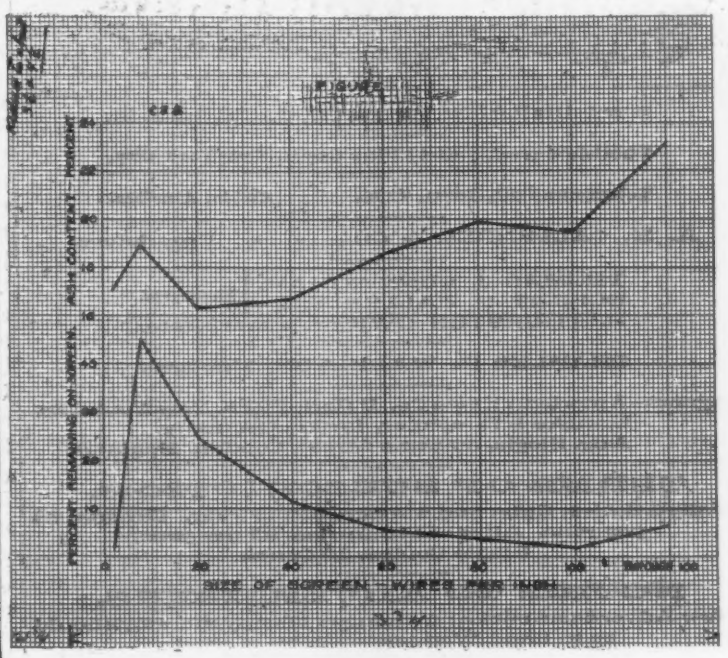


TABLE 3.—*Screening and Ash Tests of Coke Dust.*

Size of Screen Wires Per In.	Coke Remaining on Screen Per Cent. 1	2	3	4	5	Ash Content Per Cent. 3	4	5
2.....	1.93	1.30	2.46	1.45	2 10	17.06	14.58	19.36
8.....	51.04	49.55	50.03	37.75	36.75	13.56	22.05	21.25
20	23.50	29.30	21.80	24.60	23.10	16.90	15.84	16.11
40.....	9.78	7.95	10.15	14.70	14.75	16.38	17.42	16.32
60.....	3.95	2.95	4.52	7.80	8.25	17.34	18.97	19.51
80.....	2.55	2.40	3.15	5.15	4.70	17.84	20.29	21.37
100.....	1.10	0.80	0.90	2.00	3.05	18.69	18.95	20.98
Through 100	6.15	5.75	7.00	6.35	7.30	22.96	22.34	24.39

Top ..... 13.65 per cent.
Two-thirds down..... 25.28 "
Bottom ..... 36.50 "

The coke containing slate having the greatest specific weight settled nearest the bottom.

Attempts to Burn Dust in Natural Form or Mixed with Coal in Boilers Without Special Equipment or Methods.—During the early attempts to burn the dust, boiler tests were made with a 360-horse power Stirling boiler, equipped for burning both coal and blast furnace gas; that is, having a furnace with a high fire arch, varying from 4 to 5 feet above the grate, thereby giving the large combustion chamber desirable for burning bituminous coal and lean gas. It is hardly necessary to say that results in this form of furnace were not encouraging. The coke used had been passed through a screen of ⅜-inch mesh. Before the tests the boiler was run with gas, and at the start a thin layer of coal was put on the grate to form a fuel bed for the coke dust, which was then fired until there was a good, even bed of about 6 inches in depth. The gas was then turned off. A number of holes were blown through the fire almost immediately, with even the light force of natural draft, and attempts to check this effect, by partly closing the damper, resulted in a dead fire. The fuel bed was gradually built up to 10 or 12 inches, and the best results were obtained by allowing it to burn for a considerable time without firing fresh fuel. Under these conditions, a short test was run, resulting in only 20 per cent. rating. Neither the walls of the furnace nor the fuel bed were at higher temperature than a red heat, consequently the fuel was not properly ignited. With a mixture of 1 part Illinois coal and 2 parts dust another test was made under the same conditions, resulting in 28 per cent. rating.

In order to make conditions more favorable for burning coke dust, new fire arches were built, about 2 feet above the grates and 1 course of brick removed from the bridge-wall. Two argand blowers were placed so as to blow air and steam into the ash pits, and provision was made for blowing air over the fire. During a preliminary run it was found that 2 steam blowers had a cooling effect on the fire, so for subsequent tests 1 blower was operated with steam and 1 with compressed air. The test lasted but 3 hours, for when attempt was made to clean fires the greater part of fuel sifted into the ash pit. While the test lasted, 40 per cent. rating was obtained.

Another attempt was made and, by firing coal at cleaning time, a test of 7 hours duration was obtained. Natural draft was used at first, but as the fires remained dead, the blowers were started giving a blast of ⅝ inches of water under the grate. In spite of all efforts, only 32 per cent. rating and 31 per cent. efficiency were possible.

A test with hand-firing and natural draft was run on a 300-horse power Stirling boiler to determine whether a mixture consisting of

(*Continued on page* 380.)

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NEW YORK, MONDAY, JUNE 3, 1912.

BRIEFLY TOLD.

THE NAHANT OUTING, NEW ENGLAND SECTION, NATIONAL COMMERCIAL GAS ASSOCIATION.—The Committeemen (Messrs. C. H. Stevens and F. W. Mace, of Lynn; and A. H. Vegkley, of Boston) of the New England Section, Commercial Gas Association appointed to perfect arrangements for the grand outing, have surely been up to their work, for their report on the preliminaries has been presented, and that it will meet with the heartiest approval of all may not be denied. To begin with, the date is July 13th, and the place is beautiful Nahant. Nahant is one of the most popular summer resorts along the Atlantic Coast, and the ease with which it may be reached is another magnet. Starting with a sail down the harbor, which brings one through and by the many islands in the channels, and under the beetling brow of the fortified mainland, upon arriving at ever beautiful Nahant, the voyagers will journey to the recreation grounds, which will be the spot whereon will be brought off the series of sports and games arranged by the Committee. On the list we note these numbers: A baseball match, to run 5 innings, the participants to represent the married men and the single men; a sack race; a potato race; a pig-back race; a broad jump, and a dash of 100 yards. Of course, suitable prizes will be awarded the respective winners. At the close of the contests the members will journey to the Bass Point House, the head of which establishment has been ordered to furnish a shore dinner, "as is a shore dinner." Many of the most prominent gas men in the New England States have signified their purpose to be present, and members of the gas fraternity generally, whether or not members of the National Commercial Gas Association, are invited to join with the New Englanders in their trip to Nahant. Applications for tickets should be made to the Managers of the various gas companies, or to the Secretary of the New England Section, National Commercial Gas Association, Mr. C. J. Connell, 24 West street, Boston, Mass.

THE 1912 MEETING, MICHIGAN GAS ASSOCIATION.—At the last meeting of the Michigan Gas Association, held in Detroit, it was voted to place the matter, of where and when the next meeting should be held, in the hands of the Executive Committee, with instructions that a boat trip into and around the Thousand Islands of the St. Lawrence be arranged if found feasible. The Executive Committee has received from the Canadian Gas Association, through its President, Mr. Arthur Hewitt, of Toronto, a most cordial and kindly invitation to make that part of Canada their meeting place for 1912; and, therefore, after having gone into the matter thoroughly, decided to hold the next meeting on the dates, Wednesday, Thursday and Friday, September 4, 5 and 6. It is proposed to hold a combined land and water session, arranged like this: To meet the morning of the 4th in Toronto, spending that day and evening in the city; the two following days (5th and 6th) to be passed on the specially chartered steamer "Rochester," bound for a two days' trip into the Thousand Islands, the returning to Toronto to be marked by a 4-hour stopover at Niagara Falls. The first business session will be held in Toronto the morning of the 4th, and two other business sessions will be arranged for on the boat. The Canadian Gas Association will also hold its meeting about that time, and has been invited to be with the Michigan, not only in attendance at the sessions, but to participate in the boat ride and other entertainments. The Canadian National Exposition, which is one of the greatest yearly events in Canada, will be on at that time. An important feature of it will be an exhibit of gas appliances by the Canadian gas men. The Michigan contingent will also be given an excellent opportunity of visiting the gas works at Toronto, which is one of the finest plants on the Continent. A 2-day's boat ride, which includes a stop-off at Niagara Falls and a trip through the Thousand Islands and return, will surely be up to the standard of the other boat voyagings that the Michigan has so successfully undertaken. Members will likely be especially pleased this year to learn that they will be expected to invite their wives to participate in the trip. Technically, a fine programme or list of papers is being arranged, and all gas men and appliance men from the States and Canada, are invited (this entire account is virtually official) to plan for attending. Low rates (amounting not to exceed one fare the round trip) will be available at this time because of the prestige of the big Canadian Exposition. Members attending will be assured of sleeping accommodations in Toronto, the night of September 4th, in spite of the large crowds attending the Exposition, as all will be assigned to their berths on the boat, which will be turned over for the use of the Association on that date. Everything is being carefully planned for the comfort and pleasure of the delegates and their friends, and the entire expense of this trip will not materially exceed the expenses incident to ordinary meetings, and the time consumed will be no greater. Those desiring further details at this moment will receive same by addressing Mr. Glenn R. Chamberlain, Secretary, Michigan Gas Association, Grand Rapids, Mich.

OBITUARY NOTE.—A pioneer in the southern section of gas enterprise in the States passed away, when, on the morning of the 17th ult., Mr. S. E. Linton, of Raleigh, N. C., answered the last summons. Although in his 77th year (he was born in Philadelphia, Pa., September 22, 1835), his last illness did not seem serious; but some days over a month from the time he was prostrated marked its limit. As above noted, his birthplace was Philadelphia, in which city his people were well known in business and social circles. His education was obtained at Haverford, and later on he became interested in construction work of an engineering nature. If we mistake not, his first real business venture was in 1855, when he was detailed by a firm engaged in the construction of rosin gas plants, to establish one of these in Salisbury, N. C., then the capitol of the State. He designed at that time the set of gas fixtures that adorned the legislative hall of the State House, the beauty of which was matter for comment in other States than North Carolina. In 1861 he removd to Columbia to there establish a gas works. This was right at the outbreak of the terrible conflict known to history as the War of the Rebellion, and the Carolinas were about in the strongest line of the hottest battlings. His sympathies were with his Southern confreres, but not so strong as to incline him to join the rebel forces. And this rather shows how the man was regarded by his fellows. He was granted exemption from military duty by the Confederate government, and while a resident in Columbia not only supervised the production of gas, but also became largely interested in the distillation of turpentine. In fact, when General Sherman's forces started on the famous march through Georgia, on passing through Columbia, they set fire to thousands of barrels of turpentine, etc., owned by deceased and his associates. This reverse naturally blotted out the Linton fortunes; but undismayed, he journeyed further South, and constructed a gas plant in Jacksonville, Fla. (1866), returning to Charlotte, N.C, in 1875. Here Mr. (he should be really known as Capt., a title conferred on him in 1863) Linton practiced his profession to 1899, and was frequently called on for professional advice in respect of proposed gas undertakings. In that year he removed to Raleigh, at which point some time later he succeeded in molding together the in

terests of the gas and electric lighting suppliers of Raleigh, through the medium of the Standard Gas and Electric Company, of which corporation he was President and General Manager up to Jan. 1, 1912, the corporation some weeks before having disposed of all their interests to the Carolina Power and Light Company, since which time he enjoyed a relaxation from any form of business pursuit. He was a member of the Southern Gas Association, but never seems to have given much attention to this branch of methods of the fraternity. As to his personality, this sentence, forwarded us by a gentleman who knew him well, will well illustrate it: "Gentle in his manner but firm in his convictions; honest in all his dealing; a christian and a gentleman, he held a place in the life of this city [Raleigh] that will never be maintained as he maintained it." He was noted for his good works [prominent amongst these may be noted his active membership in St. Marks Lutheran Church, Raleigh, which body he helped to found], and is survived by his widow, 4 daughters and 2 sons. One of the latter (S. E. Linton, Jr.) is Superintendent of the Sioux Falls (So. Dak.) Gas Company. After suitable services the remains were removed to Charlotte, where interment was made.

NINTH MEETING OF THE "GAS MEETERS."—The ninth meeting of the "Gas Meeters" was held at up-town "Mouquin's," at 4 P.M. of the 24th inst. The meeting was called to order by Chairman Peffly, and the roll being called, the Secretary read a report on the activities of the Association, which was started September 25th, 1911, with the following "Gas Meeters" present: "Will." W. Barnes, I. W. Peffly, A. M. Berg, Stanley Grady and H. Thurston Owens. Since that time eight meetings have been held, with a total attendance of 197. The subject of revising the constitution and government of the Association was discussed, with the result that the number of Commissioners was changed from 5 to 3, whose terms of office are for 6 months, and a Secretary-Treasurer, to serve a term of 1 year. The election resulted as follows:

Commissioners.—Mr. Will. W. Barnes (Chairman), Mr. Wm. H. Pettes, and Mr. I. W. Peffly.

Secretary-Treasurer.—Mr. H. Thurston Owens.

At the conclusion of the business session the members adjourned to the banquet hall to enjoy a very pleasant meal, after which Mr. Frank W. Frueauff (Past-President of the National Commercial Gas Association and Past-President of the National Electric Light Association) addressed the members on the "Get together Spirit." He laid special stress on the importance of small and frequent gatherings of a social character, as a means of fostering and encouraging improved methods in the manufacture, distribution and sale of gas and enlarging the field of its application. Informal speeches were also made by Mr. C. F. Leonard, Engineer, New York Public Service Commission, 2d District; Mr. H. H. Ganser, President, Pennsylvania Gas Association; Dr. Lee Galloway, Director, Salesmanship Course, National Commercial Gas Association; Mr. L. R. Dutton, First Vice-President, Pennsylvania Gas Association; Mr. W. F. Hine, Gas Engineer, New York Public Service Commission, First District; Mr. T. M. Ambler, Commercial Agent, Brooklyn Union Gas Company; Mr. J. M. Brock, of the Wm. M. Crane Company. In addition to the speakers, the following out-of-towners were among the 44 present: H. H. Greenfield, Secretary, Sprague Meter Company; R. F. Pierce, C. W. Wardell and Alphonse Mason, of the Welsbach Company; H. P. Dains, Humphrey Company, Philadelphia; S. K. Campbell, F. N. Downs and H. D. Dillingham, Nassau and Suffolk Lighting Company, Long Island, N. Y.; Louis Stotz, Secretary, National Commercial Gas Association; and F. M. Roberts, Commercial Agent, Fall River (Mass.) Gas Works Company.

CURRENT MENTION—

ON May 21st, the City of Paris, France, asked for bids from the public in respect of a total subscription of $41,000,000 bonds, the monies received from such sale to go towards paying for the construction of the magnificent new gas works that is to replace the present somewhat mis-related separate plants. The bonds have a par value of $60 each, and it was determined to put them on the market at $57 each (the interest return is equal to about 3.68 per cent. per annum), the offering to last for 1 day. The issue was over-subscribed 80 times; and at the close of the subscription a premium of 4 francs (about 80 cents) was freely offered for the security.

MR. C. C. FOLGER, General Manager of the Civic Utilities of Kingston, Ontario, Canada, meaning that he has under his care the Water, Light, Heat and Power Departments of Kingston's Municipality, seems to be keeping up his reputation as a first-class hustler. Strengthened belief comes largely from the perusal of a small pamphlet which was recently distributed amongst the inhabitants. It briefly details the progress that is being made in the civic divisions named, and the specifying proves that Manager Folger is not in any sense neglecting the gas section of the aforesaid municipal utilities. In fact, 'tis quite the reverse, for the clever Mr. Folger reports that 5 years ago the output per annum was 26 millions cubic feet, whereas the output for the last twelvemonth will well exceed 50 millions. Our readers may remember that some weeks ago the Gas Machinery Company installed a new water gas plant to Manager Folger's order.

ON the application of a stockholder in the corporation, the Tri-State Loan and Trust Company, of Fort Wayne, Ind., has been appointed temporary receiver for the Kerr Murray Manufacturing Company, of Fort Wayne. The receiver is in no sense or manner interested in the Company, not being a creditor thereof. The Company is perfectly solvent, the assets being far in excess of its liabilities; but to secure itself against what possibly might embarrass it along other lines, this step was taken to protect all. The business will not be interrupted, and the receivership will enable it to secure quick funds to carry on its trading without a break. We repeat it, the Company is safe from any viewpoint.

MR. SAMUEL C. SHAFFNER has resigned from the place of General Manager of the Eastern Power Company, Easton, Pa., to accept a responsible place on the staff of Messrs. Kelsey, Brewer & Co., the well-known operators of gas and electric properties, whose headquarters are in Grand Rapids, Mich.

Publications.

[All Publications, Catalogues, etc., mentioned below, are kept in our office for the convenience of our patrons.]

Directory of Gas Companies.—Brown's "Directory of Gas Companies," for 1912, contains nearly 100 more pages of data than the volume for the preceding year. The Directory, which is in its 25th year, includes reports from 2,090 gas companies, which may be separated as follows: Artificial, 1,102; natural, 547; acetylene, 206; gasoline, 119; parent, 116. A noteworthy feature of the current edition is the quantity of data given respecting the various companies listed.

Baltimore Gas and Electric News.—The family publication of the Baltimore Consolidated Gas, Electric Light and Power Company is enjoying healthy prosperity. Its fourth number, dated May, contains the work of a large number of contributors. The single feature of co-operation shows that the work of Editor Hawks has stimulated and sustained the interest among the employees.

Gauges.—The Bristol Company is distributing Catalogue No. 1,000, which for completeness and "readability" sustains the reputation of this Company, both in publications and in apparatus.

Mine Fires.—The Bureau of Mines has issued, as technical paper No. 13, a report on "Gas Analysis as an Aid in Fighting Mine Fires," by Messrs. S. A. Burrell and F. M. Seibert.

Atlanta, December 2d to 8th.—We are reminded that there will be a "big" gas show at Atlanta next December, by a post card photo of "The Georgian Terrace," Atlanta's new million dollar hotel. If Chairman Rushin goes after the N. C. G. A. members with the same enthusiasm that he exhibits in following up the "prospects" at home, there will undoubtedly be a big attendance at the show. Are the other Southern Companies doing their share to boost Atlanta's "Gas Show?"

Clark Jewell Handbook.—An attractive handbook of gas stoves, N. C. G. A. standard, has been issued by George M. Clark & Co. The book contains about 50 sheets and gives the data covering each of the appliances.

Coal Storage.—Technical Paper 16, issued by the Bureau of Mines, Department of the Interior, is a preliminary report on deterioration and spontaneous heating of coal in storage, by Messrs. H. C. Porter and F. K. Ovitz.

Gas Cooking Ranges.—A veritable directory of the "best" in ranges and appliances will be found in a well illustrated pamphlet recently issued by the Peoples Gas Light and Coke Company, Chicago.

(*Continued from page 377.*)

75 per cent. coal, 18 per cent. coke dust, passed through a ¼-inch screen, and 7 per cent. coke breeze, passed through a ¾-inch screen and over a ¼-inch screen, would give satisfactory service when fired under boilers. The coal contained a great deal of slack and dust, so that when mixed with the coke dust the proportion of fine material was very large. During the first part of the test this fine fuel interfered so much with combustion, by clogging up the grates and interfering with the air supply, that it was difficult to keep the fire burning. Conditions were better during the latter part of the test, but not satisfactory. The great difficulty was in getting the fuel to burn. Only 47 per cent. rating was obtained at an efficiency of 44 per cent. Possibly under different conditions, using a good grade of nut or lump coal, satisfactory results might be obtained.

This test was followed by one under similar conditions on a 412-horse power Stirling boiler, using dust passing through a ¼-inch screen, resulting in 42 per cent. rating and 45 per cent. efficiency. These failures are due, without question, to the fineness of the fuel, which clogged the grates causing a generally cold state of the combustion chamber.

Similar attempts were made to burn the dust, with natural draft, on a chain grate under a Stirling boiler, but the results proved conclusively that it could not be economically burned in such a manner, either alone or mixed with coal. Chain grates operate most successfully with a coal containing a high percentage of volatile matter and offer the cheapest and best means of burning Illinois coal with a high volatile content. The reason for this is that, with a chain grate, the point of entry of the coal is the coolest part of the furnace and so the coal is ignited gradually. The volatile matter is slowly released from the fuel, thereby avoiding fracture of the coal into fine particles to be carried away in smoke, as occurs in the use of ordinary hand-fired grate; while the gases that are released are drawn between the hot fire arch and the incandescent coal bed, allowing the hydrocarbon gases to be thoroughly mixed with air and completely burned before striking the boiler tubes. With Pocahontas, and other coals having a comparatively low percentage of volatile matter, the chain grate does not operate so successfully, due to the coal not igniting readily; but, when ignited, and the boiler forced to capacity, the coal produces such a high temperature in the furnace that the fire arch is melted down. Coke requires a high temperature for ignition, and as there is practically no volatile matter, success need not be expected in this application.

In connection with these early attempts to burn the dust, it may be of interest to know that several years ago extensive tests were made on Stirling boilers, using coke dust as pulverized through an "Aero Pulverizer," and delivered to a specially prepared furnace under the boilers. It was found impossible to sustain the combustion of this finely divided coke under favorable conditions of air supply and in the absence of any steam in the combustion chamber, unless there was a considerable portion of coal passing through the machine. Even with these concessions in mixture, the presence of coke dust seems to indicate that it was a little more than an inert agent in the combustion chamber.

As a result of these various experiments, the conclusion was reached that the use of coke dust in the natural state, under any boilers, was not possible unless a reduced output and efficiency be accepted, or unless favored by special equipment and methods. The main obstacles were fineness, the necessarily high ignition temperature and high ash content. There also seemed to be evidence that the mixture of considerable quantities of coal with the coke dust, in application to boilers with a natural draft, would not materially affect the exhibit of a very much reduced output of boilers, as compared with their rating.

The favorable results obtained in the tests made with the coarse breeze (Appendix I.) compared with the failures with the dust, demonstrated that the size practically determined the degree of success when burned in ordinary furnaces. The briquetting process seemed to offer attractive solution, since, in addition to combining the dust into larger units, the addition of some soft coal of low ash content would supply the needed volatile matter for accelerating ignition, as well as reducing the average proportion of ash. Consequently, a series of briquetting tests were conducted with various binders and coal mixtures, tests made of the briquets in various applications, and in general, the investigation was carried far enough to indicate that success might be expected, provided there could be found for the briquets a market such as would pay a suitable return on the necessary investment for a plant, and, at the same time, give to the reclaimed dust a value as nearly as possible to the value of the large sized coke of which it formerly was a part.

However, the briquetting process was only one method of meeting the problem, and it was recognized that success might attend the use of coke dust, without any special preparation of the same, such as briquetting, by the evolution of exceptional means favoring the peculiar conditions seemingly required by a fuel with the characteristics of coke dust. Among other things, it was absolutely certain that a better control and greater flexibility of air supply than was customary in boilers would be necessary. Attention was, therefore, turned to such classes of apparatus as would provide control of air supply, forced combustion and mechanical delivery of fuel to the fire, and it was decided to carry on experiments with the "Jones Stoker," manufactured by the Under-Feed Stoker Company of America, and the Parson System, owned by the Parson Manufacturing Company, New York, each of which seemed to fulfill the requirements.

Use of Special Apparatus and Methods as Aids to Successful Burning in Boilers.—The Jones Stoker was tested first. The boiler equipped with it was one of a battery of the ordinary horizontal return tubular type of 150 rated horse power.

Fig. 2 is a cross-section of a typical installation of this kind, showing the character of fuel bed and the blast pipes for distributing air from

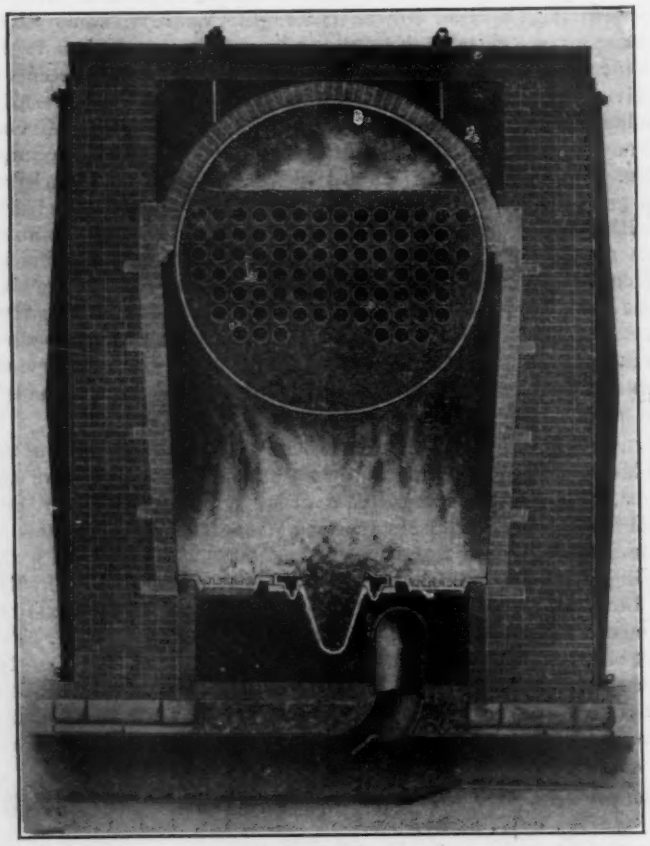

Fig. 2.

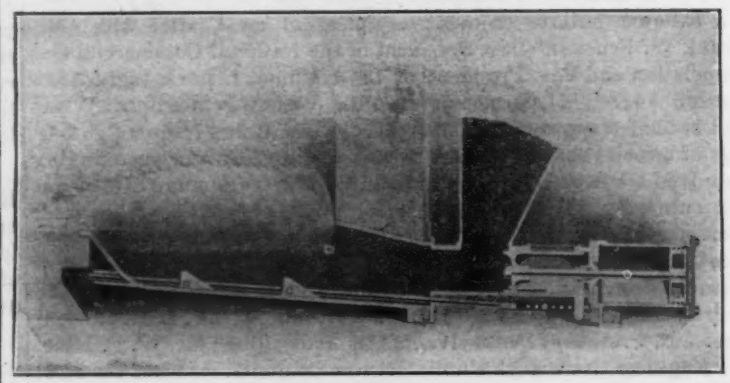

Fig 3.

TABLE 4.—*Boiler Tests with Coke Dust and Coal Mixture in Jones Stoker.*

Test No.		1	2	3	4	5	6
Duration	hours	8	8	7	7	7	
Feed temperature	deg. F	20.96	20.85	21.01	20.96	207.4	207.4
Steam pressure	lb. ga.	87.7	87.9	87.8	88.0	88.8	88.9
Blast pressure	in. water	3.65	3.02	2.8	3.1	3.21	3.38
Draft over fire	in. water	.18	.20	.17	.18	18	.20
Total time blast was off	min.	20	85	20	45	21	42
Total fuel mixture per hour	lb.	783	819	726	642	794.3	697
Proportion coke dust in mixture		0	0	1/3	1/2	3/4	2/3
Total refuse from test	lb.	889	649	297	642	.356	808
Actual water per hour	lb.	7100	6320	5190	4465	5090	5020
Equivalent per hour	lb.	7300	6870	5400	4620	5290	5220
Boiler horse power developed		214	190	157	136	154	152
Percent of rating developed		143	127	105	91	103	101
Actual evaporation per lb. fuel,	lb.	9.07	7.72	7.16	6.92	6.40	7.20
Equiv. evaporation per lb. fuel,	lb.	9.45	8.05	7.45	7.20	6.66	7.48
Assumed equiv. evap. per hour by Coal, allowing 8.6 per lb.	lb.	6740	7040	4160	3760	1708	1998
Equiv. evap. allowed to coke dust,	lb.	-	-	1240	1040	3582	3228
Equiv. evap. per lb. coke dust,	lb.	-	-	8.14	8.79	6.01	6.94
Heat value of coal, natural	B.t.u.	10913	11339	10601	10928	9743	10309
Heat value of coke dust, natural	B.t.u.	-	-	9996	10326	11389	10086
Heat value of mixture	B.t.u.	10913	11339	10320	10570	10960	10480
Efficiency of boiler and furnace,	%	69.7	66.1	68.7	66.1	58.9	69.2
Analysis of dry coal, Volatile Matter	%	42.30	40.80	39.65	40.80	42.35	43.90
Fixed Carbon	%	45.05	45.20	43.55	45.90	46.15	45.45
Ash	%	12.65	14.30	16.80	13.25	13.50	10.65
Sulphur	%	5.00	5.40	5.85	4.60	4.35	4.20
B.t.u. dry		12258	12050	11737	11988	12060	12230
Moisture	%	10.80	8.90	9.60	9.85	19.30	9.67
Analysis of dry coke, Volatile Matter	%	-	-	2.35	3.20	3.80	2.95
Fixed Carbon	%	-	-	74.10	74.10	76.10	74.75
Ash	%	-	-	23.65	22.70	21.40	22.30
Sulphur	%	-	-	.70	.65	.80	.78
B.t.u. dry		-	-	11426	11613	11998	11426
Moisture	%	-	-	12.80	11.10	4.16	12.80

fans to a number of boilers. The stoker is illustrated in Fig. 3. The fuel falls from the hopper, in front of a steam-driven ram, which delivers it to the retort, around the upper edge of which is a row of tuyere blocks containing narrow slots for the admission of air from the air-tight ash pit directly into the burning fuel. Extending from either edge of the retort to the side walls are the dead plates on which the ash and clinker gradually accumulate and are withdrawn therefrom through cleaning doors, without disturbing the fuel bed. The action of the ram, as well as the fan speed, is regulated by steam pressure, so that as low pressure requires a frequent delivery of coal to the retort, it is accompanied by increased blast pressure and the proper proportion of air for perfect combustion. The steam supply for the various rams, and the exhaust therefrom, are controlled through a bank of rotary valves operated indirectly by the fan engine.

Tests were made (first with Indiana coal), with the object of finding out the capacity of the boiler with the coal in order to have a standard with which to compare the performance when using coke dust. These two tests did not show very uniform results, due to the trouble with extreme variations in the rate of feeding water to the boilers. The average, however, was very close to the average results obtained in other tests at the power house. The coal tests were followed by 4 others, using mixtures of coke dust and coal, containing ¼, ½, ¾ and ¼ coke dust. The feeding was watched carefully to prevent the extreme variations found in Tests 1 and 2. The principal results are shown in Table 4. On all the tests the air blast was occasionally lost, due to the high steam pressure operating the automatic control of the fan engine, usually for 3 minutes at a time, when very little air got through the fire. The burning of coke dust was a new field to those in charge, so that some experimenting was done during Tests 3 and 4. At first the fire was kept rather low, but it was found that the coke dust was blown out and piled up at the sides of the dead plate without burning. The tuyere blocks in the stoker during Tests 1, 2 and 3 were of the type regularly used, having 2 air openings each, and as the fire channeled badly, they were replaced, between Tests 3 and 4, by new blocks having 4 openings each.

After Test 3, the fire was kept piled up higher and the fan speeded in order to get the greatest blast pressure possible. The limit of blast pressure seemed to be about 4 inches at the boiler tested, but, because of the fluctuating loads on the power station, it was found impossible to keep the blast at a constant pressure under the operating conditions existing.

By an inspection of the test results, it will be seen that Test 6, with a mixture containing ¾ coke dust, gave the highest equivalent evaporation, being 6.94 pounds, per pound of dust, which compared with 8.6 pounds for an average of the coal tests, indicated that the dust had a fuel value of 80 per cent. that of the coal. None of the tests with coke dust showed as high capacity as with coal, but it was evident that neither the operating conditions nor the stoker details were quite suitable for this special fuel. Better results could have been obtained with higher and more uniform blast pressure. The dust burns only when air is forced through it, but if the blast is too strong, channeling occurs. It was evident, from the appearance of the fire during these tests, that the ordinary form of dead plate was not best suited for burning coke dust, as the dust piled up out of range of the blast and did not burn rapidly enough there to be much of a factor as a heat producer. The fire area was not only cut down thereby, but the material was in the way when cleaning the fires. In view of the test results and observed characteristics of the stoker operation, the conclusion was reached that in all probability the Jones stoker, with certain modifications in tuyere blocks and dead plates, would give sufficiently high boiler efficiency and capacity to make an economical disposal of the coke dust.

The performance of the Parson system at several plants was examined to find out some of its more important characteristics before installing an equipment on which to make tests under the particular conditions in hand. Visits were made to the boiler plants in the Connelsville district where the problem was with bee hive coke refuse, as well as to some by product ovens, and as a result of observations, the following conclusions may be offered:

(a) A forced draft of ¼ to 1 inch of water column in the closed ash pit with admission of steam with the aid supply is imperative.

(b) A suitable form of stationary grate with small and numerous air openings is indispensable. This may take the form of the "pin-hole grate," so-called, or the herring-bone type, having narrow slots.

(c) With the above concessions, coke dust may be economically burned when fired either by hand or by means of the Parson distributor, to be described later.

Steam must be delivered under the grates for the purpose of breaking up clinker, although it is not necessary to use live steam for this purpose if air can be delivered by other means than injector blowers. The latter devices will use from 2 to 8 per cent. of the total steam produced by the boiler, while an available exhaust steam supply and independent delivery of air will simply add to the output of the boiler by this amount, neglecting the small amount of power which a positive air delivery would impose. Whatever the type of blower the air delivery resulting therefrom must insure the maintenance of a suitable high pressure in the ashpit as a first consideration. With any system of blowing it is desirable to have the means of control near the fireman. As the force of the blast carries considerable quantities of fine dust and ashes over the bridge wall, it is evident that good results could not be obtained from economizers or superheaters, which would be rapidly covered with a deposit. The refuse blown over the bridge wall may be 12 or 15 per cent. of the total fuel, when the boiler is operating at rating, and increases to 25 per cent. or more at the high overloads. Analysis of this refuse shows about 20 per cent. ash.

Shaking grates are not recommended, since undisturbed flat surfaces simplify the handling of the fires, and it is found more economical to clean the fires through the fire doors on to wheelbarrows. Whether pin-hole or herring-bone grate bars are used, the openings therein should not be greater than about ½ inch in diameter or width, and must be larger at the bottom than at the grate surface, in order that they may not become clogged. The total area of air openings usually amounts to about 7 per cent. of the total surface for pin hole grates and 25 per cent. for herring-bone; a higher blast being required, of course, with the smaller openings.

Ordinary firemen do not produce good results unless stimulated by a bonus system, or paid a uniformly high wage. At one plant a bonus system was started, consisting of paying $2.75 per 8-hour day, if the steam pressure was kept above 100 pounds, while any drop below that point meant that the men received their former rate of $2 per day. After the firemen had become trained, however, a uniform rate of $2.75 without bonus was paid. The labor is so exacting that the men cannot withstand longer than 8-hour days. The fires must be leveled frequently in order to prevent burning through in spots, and they must be cleaned every 2 to 4 hours, requiring 20 minutes or more for each cleaning.

The Parson distributer, shown in Fig. 4, consists of a steam-driven injector blower, which intermittently draws gas from the boiler furnace and projects it at high velocity against a small portion of fuel which is simultaneously delivered into the path of the gas by a reciprocating pusher. The fuel is thus scattered to all parts of the furnace, the lateral distribution being accomplished by curved vanes which direct part of the flow of gas toward the sides of the furnace. The moving parts are contained in a cast iron box incased in the brickwork of the boiler front and are propelled by a connecting rod and an eccentric on a line shaft. The power for driving is insignificant. The air pressure under the grates is furnished by one or more injector blowers, usually located at the rear of the boilers, with delivery pipes under the bridge wall. The steam connections, for both the distributer and blower, are from the same source of control, so that when the blowers are shut off by hand, or automatically by high steam pressure, the distributer action is also interrupted by means of a steam-actuated clutch on the reciprocating fuel pusher. The range of capacity is from 400 to 3,000 pounds of fuel per hour. The labor requirements are not greatly different from coal-fired boilers, for although there is no hand firing of coke dust, the greater percentage of ash necessitates frequent cleaning and removal of refuse; moreover, the fires must be kept leveled.

The results of a number of boiler tests are shown by Appendix II. They are divided into several groups, "A" being tests with beehive coke dust on a boiler equipped with Parson grates, blowers and distributers; "B," tests with by-product dust on another boiler having only the Parson blowers and hand-fired pin-hole grates; and "C," test on the latter boiler after having been equipped with fuel distributer.

The dust used in the "A" tests was from charges which had been 48 and 72 hours in the coking process, consisting of fork drippings and sweepings from the loading dock in front of the ovens and refuse remaining in the ovens after the charge was pulled. It contained coke of all sizes, but mainly fine dust. The distributer is not as suitable for handling the miscellaneous sizes of fuel as some fairly uniform size, on account of the larger pieces falling from the distributer outlet and forming a pile near the fire doors, requiring further spreading by the fireman. This plant is equipped with a Parson pneumatic,

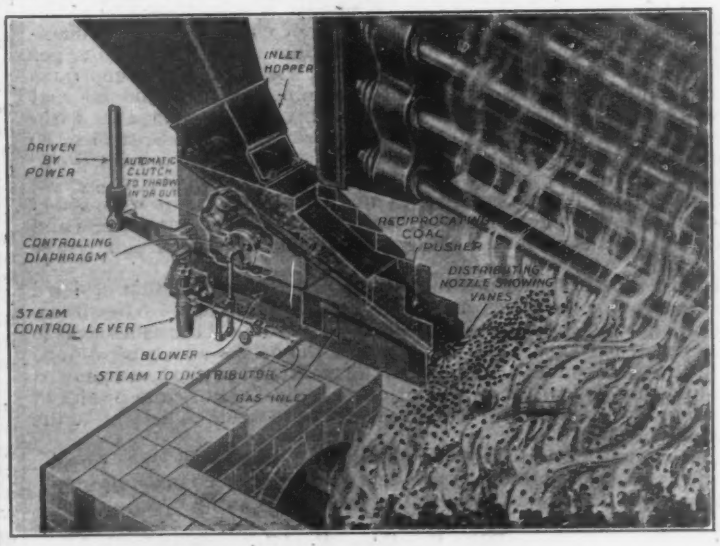

Fig. 4.

fuel-handling apparatus for delivering the coke dust from a pit outside the boiler house to storage hoppers over the boilers. The essential results of these tests are that the evaporation per pound of fuel is about ¾ as much with coke dust as with coal, but the efficiency was

about the same, due to the difference in B.T.U. values; also, the boiler capacity, with coke, was only a little more than ½ that with coal. However, it is believed that Tests 1 and 2 with coke do not show the maximum capacity; since Test 4, with 15 per cent. total added, gave a third more horse power.

The "B" tests were with by-product dusts of a size under about ¼ inch and Illinois coal, fired by hand. The capacity and boiler efficiency with coke dust were only slightly below the results with coal. Tests 4 and 6, both with coke dust, show considerable difference in efficiency, since test 4 was run by the men who installed the apparatus, while test 6 was run by the men of the regular boiler house force and who were somewhat inexperienced with the apparatus.

Test "C" shows the improvement due to the fuel distributer, in spite of the quality of the coke being very poor, containing 18 per cent. moisture and being mainly under $\frac{1}{16}$ inch. The distributer had the effect of increasing the overload capacity from about 140 to 153 per cent., while the efficiency remained practically the same. Had the quality of the fuel been similar to that in Test "B," doubtless better results would have been shown. On the whole, the Parson system gives very commendable performance with even the poorest grade of fine, wet and dirty coke dust.

These tests with the Jones stoker and the Parson system show in a general way the possibilities of special apparatus and methods. Doubtless some other types of mechanical stokers, with forced draft, would lead to similar results, provided some coal be added to assist ignition.

Briquetting Process.—The boiler tests made with coke breeze of a size between ¼ and 1 inch, shown in detail by Appendix A, indicated that the size of the coke was the principal element in determining the degree of success as compared with coal. It seemed, therefore, that if the fine dust could be collected into larger units, it would give similar results, and an investigation of the possibilities of briquetting was started, during which the following facts were developed. Due to the high ignition temperature required for coke, none of the binders tried, including molasses, dextrine, lime and Portland cement, evaporated sulphite liquor and glutin, a commercial form of the same, would successfully hold the dust together in the fire. The sulphide pitch and dextrine gave the best results. The sulphite liquor is a by-product in the manufacture of wood pulp. Finely divided wood is treated with sulphurous acid, which removes about 50 per cent. by weight, leaving the fiber, which is made into wood pulp and paper. This waste liquor has no considerable market and is produced in such enormous quantities that the disposition of it is said to be a serious problem. On evaporation, there is obtained a pitch which has a binding quality, suitable in many respects for briquets. The peculiar quality of this pitch is that briquets made therewith do not readily disintegrate when heated. No attempt was made to use coal tar and pitch because of the lack of facilities for properly handling them. Soft pitch requires melting before mixing with the fine fuel and provisions for keeping hot during briquetting, while hard pitch requires grinding to a fine powder and, after mixture with the fuel, heating to obtain the proper condition for pressing. Coal pitch is successfully used as a binder for coal briquets, but has the disadvantage of causing excessive smoke. Sulphite pitch produces no smoke, but the briquets made therewith are not weather-proof and disintegrate if allowed to remain wet. They also require drying in ovens or otherwise before handling.

It was found that, with a mixture of coking coal, sulphite pitch and coke dust, a briquet could be made that would burn with only slight disintegration. Various proportions of coal were tried, from 10 to 50 per cent., and the best briquets were made with a mixture of 15 per cent. coal, although very little difference could be distinguished in the briquets until the proportion of coal was increased to something over 35 per cent. At 10 per cent. of coal the briquets disintegrated under heat slightly more than those made with 15 to 25 per cent. of coal. As a result of experiments with different proportions of coal and binder, it was decided to use 15 per cent. Pocahontas coal and 3 per cent. sulphite pitch as the most favorable mixture for withstanding handling and high temperatures. As only about 25 or 30 tons were needed for testing, the briquets were made in a brick press. They measured 8½ by 4½ by 2½ inches, and had 2 deep grooves across one side to facilitate breaking into smaller pieces. They were tested to determine their usefulness in comparison with coal in boilers and water heaters for house heating, suction gas producers and power boilers.

This action in house heating plants was similar to that of hard coal, except for the effect of the greater amount of ash. After burning all night, it was necessary to shake down some of the ashes so as to open up air passages. The size was ¼ of the bricks above mentioned or about 2-inch cubes. In general, the results were good and showed encouraging possibilities. The briquets ignited readily and produced an intensely hot fire. No measurements were made to determine the economic results.

In a suction gas producer driving an 11.5-inch by 16-inch, 4-cycle, single acting gas engine, the briquets gave results comparing favorably with anthracite pea coal as to gas analysis and power.

	CO_2.	O.	CO.	H.	CH_4.	Mean Effective Pressure or Engine Card.
Coal.....	3.2	.13	26.9	14.5	..	60.0
Briquets ...	4.5	.40	27.3	5.9	.3	59.0

The boiler tests shown in Table 5 were made to show the difference between coal and briquets on hand-fired Stirling boiler of 3,465 square feet surface, rated at 345-horse power, and having 70.75 square feet of grate area. The grate bars being of herring-bone type, the furnace arch was high above the grate and, therefore, not suitable for a fuel of low volatile matter. The coal tests 1 and 2 were made under the usual operating conditions. Test 3 was made using briquets broken into 6 pieces. In order to build up the fires quickly, a large amount of coal was thrown into the fire and briquets added before the coal was entirely ignited. The briquets were added rapidly until a thickness of about 6 inches was reached. It was found that a thin fire of briquets produced very little heat so that a thickness of 9 or 10 inches was carried. About 800 pounds of coal were fired after cleaning, to build up the fires. The tests were stopped at the end of 7 hours to avoid the expenditure of briquets necessary to build up the fires after a second cleaning. This doubtless gives more favorable results than would have been obtained if the fires had been cleaned again during the test. The results shown, however, could doubtless be obtained as an average for regular operation with the improvements in the method of cleaning that would be developed if this fuel were to be used for any length of time. Test 4 was made, using briquets in about the same way as Test 3, except that greater care was taken to keep the firing door closed. The furnace temperature during this test averaged about 2,700 F., and seemed to burn with a higher temperature and with greater evenness over the grate area than in the other tests with briquets. The fuel gave out at the end of 3½ hours, which brought the test to an end. No cleaning was done during the test. On the previous test a slicing bar was occasionally run under the fire to loosen up the clinker next the grate to allow the air to get through the fire. On this test it was found that the fire burned freely until the end of the test, when the slicing bar was used under one or two places where the fire was not burning freely. With the briquets little or no smoke could be seen, except when the coal was fired after cleaning. On the Ringelmann Chart the smoke would be graded as between 0 and No. ½ or between 0 and 10 per cent.

TABLE 5.—*Boiler Tests with Coal and Coke Dust Briquets.*

		Coal		Briquets	
Test number		1	2	3	4
Length of test	hours	7.5	7	7	3.5
Steam pressure	lb. gauge	115.0	112.0	120.0	121.5
Draft over fire	in. water	.45	.45	.45	.45
Feed temperature	deg. F.	34	39.5	53.75	36.5
Stack temperature	deg. F.	567	618	675	647
Coal, total	lb.	18000	17600	800*	
Coal, average per hour	lb.	2400	2515	114	
Briquets, total	lb.			10744	7235
Briquets, average per hour	lb.			1534	2068
Total fuel average per hour	lb.	2400	2515	1648	2068
Actual evaporation per hour	lb.	11960	12600	10940	11880
Actual evaporation per lb. fuel	lb.	4.98	5.01	6.64	5.60
Equiv. evaporation per hour	lb.	14680	15400	13450	14220
Equiv. evaporation per lb. fuel	lb.	6.115	6.12	8.16	6.88
Gas analysis, average CO_2	%	6.6	7.22	8.2	9.6
O	%	13.06	11.8	14.54	10.2
CO	%	0.0148	0.08	0.0	0.0
Heat value of coal, natural	B.t.u.	9926	9948	(9926)	
Heat value of Briquets, natural	B.t.u.			12850	12568
Heat value of mixture, natural	B.t.u.			12460	
Efficiency of boiler and furnace	%	80.7	80.7	63.5	73.9
Boiler h.p. developed		426	446.5	390	415
Percent of rating developed		123.5	129.5	113	120
Analysis of fuel-Volatile matter	%	34.23	40.77	7.80	6.61
Fixed Carbon	%	49.21	43.74	74.84	74.09
Ash	%	16.56	15.49	17.28	19.16
Sulphur	%	2.66	3.12	.94	.80
B.t.u., dry		11301	11301	12811	12847
Moisture	%	12.15	12.00	1.25	1.43

*Coal used for rebuilding fires after cleaning only.

The information obtained in this investigation with briquetting, although not entirely satisfactory in some details, was sufficient to indicate a profitable disposal of coke dust. The shape and size of the briquets require careful consideration, and doubtless the best guide to the manufacturing proposition, as a whole, is the experience of the Semet-Solvay Company in developing a commercial briquetting plant at Detroit, Mich., for coke dust. There are practically no unsolved mechanical problems in the way of accomplishing a satisfactory briquetting of coke dust, coal or some other fuels. The determining condition is the acceptability of briquets as a substitute for other forms of fuel on the local market. To create a demand, they must excel the usual fuel supply in one or more respects, such as low price on the heat basis, comparative smokelessness, size suitable for purpose intended, minimum of dirt in handling, minimum of clinker and ash. The cost of manufacture, including operation of plant, selling expense, interest and depreciation, binder and coal used in the mixture, but no value set on the coke dust, would not be over $2.50 per short ton, and might be as low at $1.75.' Assuming a selling price of $5 per ton and a manufacturing cost of $2.50 for briquets containing 82 per cent. dust, the coke dust would have a value of $3.05.

Returning to Ovens as Part of the Charge.—By far the most alluring scheme for reclaiming the waste was that of returning the normal output of dust to the ovens with the coal charge, and thus solve the problem locally. If this could be done without increasing the percentage of dust, and without deteriorating the regular coke, it was obvious that the greatest economy would be realized. The attempt was made, and after a series of oven tests, starting with the dust as taken from the screening station and followed by gradual refinement in sizing and mixing, the object was finally attained. By pulverizing the dust so that it would pass through a $\frac{1}{16}$ sieve, and thoroughly mixing with the crushed coal before charging the ovens, it was found that 5 per cent. could be added, while the resulting coke was in no perceptible way inferior to the regular output. It was different in some respects, such as being remarkably tough, cell structure rather irregular, central parting not so conspicuous, and, in fact, the average size was larger than usual. The yields of breeze and dust were

not increased over normal performance; moreover, the chemical and physical tests failed to show any ill effect. So far as the indications at the ovens were involved, the experiments were a success, but as only a few ovens were so charged, the critical test of the coke—namely, its action in the blast furnace—could not be made. With an existing equipment of coal handling apparatus, crushers, mixers, storage bins, etc., alterations to accommodate the additional feature of mixing pulverized coke dust with the charge would be too expensive to make the adoption of this scheme attractive. For a new coke plant, however, there appears to be no reason why it should not be undertaken. The economy is measured by the saving in cost of coal displaced, from which must be deducted the profit on by-products absent from the dust, the cost of preparing and handling dust, and the fixed charges applying on the additional equipment. Roughly, the dust would assume a value about 70 per cent. of the cost of the regular size.

Conclusions.—As a general result of this investigation, involving a variety of projects, it may be said that the policy governing the final selection was that of following up the method involving the least first cost and at the same time giving the assurance, based on definite data, that it would work out well in actual operation. Since the production of dust might be subject to an uncertain amount of reduction, due to possible modification in the practice at the ovens, it would not have been advisable to invest a great amount of money until the minimum output of refuse was definitely known. The proposition of briquetting and returning to the ovens, although apparently giving a high value to the dust, are enveloped in some uncertainty as to economical success, the former being so largely dependent upon the local coal market and the latter not being of assured success by furnace test; moreover, both demand large investments. As mentioned early in this paper, a possible, as well as attractive, method of usefully disposing with the dust is by gasifying it in a producer especially constructed for rapid gasification by high pressure air delivery, accompanied by liquefaction of the ash by suitable fluxes, but this has not as yet been fully developed. Finally, it may be said that, for the time being, in burning the dust in boilers equipped with special apparatus for automatic control of fuel and air supply and forced combustion, those interested in this investigation believe the most satisfactory solution has been found.

This resumé of experiments, extending over several years and in different localities, is given to you, not so much as a report of the conclusions arrived at with the particular problem that demands this investigation, but as an accumulation of tests and suggestions which it is hoped will prove of some assistance to those having to deal with a similar problem. For the use of data the author desires to thank his associates, Messrs. F. G. Gasche and C. E. Moulson, of Chicago; and C. T. Mason and T. V. Salt, of Joliet, Ills., who conducted the work which is the subject of this paper.

Appendix X

Boiler Tests.

Comparative Results with Illinois Coal and one-inch Coke Breeze.

		Coal Tests.			Coke Tests.			
Test No.		4	7	9	5	6	8	10
Duration	Hours	8	8	8	8	8	8	8
AVERAGE PRESSURES								
Steam at boiler by gauge	lb.	131.7	125	117.9	120	126.7	115	127.4
Draft in uptake	In. Water	.72	.77	.73	.7	.75	.77	.85
Draft in Furnace	In. Water	.32	.45	.41	.5	.56	.39	.45
Draft under grate	In. Water	.065	.05	.02	.11	blast .12	.05	.08
AVERAGE TEMPERATURES								
Feed water entering boiler	deg.F.	72.7	127	128	126.6	127.4	128	122
Escaping gases	deg.F.	593.6	594	592	640	715	668	653
FUEL AND ASH								
Total fuel as fired	lb.	18900	20565	17539	15600	19450	17400	16750
Total dry fuel	lb.	17220	18930	15490	13880	17370	17000	16360
Total refuse as removed	lb.	3269	2583	3012	2591	2263	2779	2926
Total dry refuse	lb.	2720	2170	3421	2252	1960	2165	2623
Total combustible consumed	lb.	13734	16327	12754	11343	14538	13918	13309
Proportion dry refuse in dry fuel	%	15.8	11.46	22.1	16.26	11.30	12.73	16.0
ANALYSIS OF FUEL AS FIRED								
Fixed carbon	%	38.02	41.21	38.00	74.56	75.33	81.10	82.42
Volatile matter	%	37.43	39.92	28.72	1.28	1.12	1.91	1.81
Moisture	%	8.90	7.88	11.66	11.00	10.66	2.27	2.32
Ash	%	15.66	10.99	11.62	13.16	12.89	14.72	13.75
ANALYSIS OF FUEL, DRY.								
Fixed carbon	%	41.80	44.72	43.01	83.77	84.32	83.01	84.41
Volatile matter	%	41.00	43.36	43.84	1.44	1.25	1.96	1.85
Moisture	%	0.0	0.0	0.00	0.0	0.0	0.00	0.00
Ash	%	17.20	11.93	13.15	14.79	14.43	15.03	14.04
Sulphur, separately determined	%	3.04	4.10	4.17	.78	.78	.65	.64
ANALYSIS OF REFUSE AS REMOVED								
Combustible	%	16.12	13.27	18.21	18.96	14.67	19.13	14.45
Ash	%	67.08	70.73	71.5	67.93	71.93	58.81	75.55
Moisture	%	16.80	16.00	10.29	13.11	13.40	22.06	10.00
FUEL PER HOUR								
Fuel as fired	lb.	2362.5	2569	2192.4	1950	2431	2175	2094
Dry fuel	lb.	2152	2366	1936	1736	2169	2125	2045
Combustible	lb.	1717	2041	1594	1418	1817	1740	1663
Dry fuel per sq.ft. G.S.	lb.	25.8	28.4	23.2	20.8	26	25.5	24.2
Combustible per sq.ft. Htg.	lb.	.451	.512	.400	.356	.456	.437	.417
CALORIFIC VALUE OF FUEL								
Per lb. dry fuel	B.t.u.	11460	12205	11737	12547	12547	12407	12812
Per lb. combustible	B.t.u.	13540	13650	13810	14730	14720	14610	14910
WATER								
Total fed to boiler	lb.	100900	125739	108120	98029	127350	111885	107630
Equivalent fed to boiler from and at 212°	lb.	120000	152500	116000	108000	134300	119500	115800
Quality of steam	%	99.7	99.8	100	100	100	100	100
Actually evaporated, corrected for quality	lb.	100600	123500	108120	98021	127350	111885	107630
Factor of evaporation		1.188	1.071	1.0728	1.071	1.071	1.0678	1.0763
Equivalent evaporation, dry steam, from and at 212°	lb.	119600	132300	116000	105000	136300	119500	115800
WATER PER HOUR								
Fed to boiler	lb.	12612.5	15467	13515	12254	15919	13985.6	13454
Actually evaporated, corrected for quality	lb.	12575	15438	13515	12254	15919	13985.6	13454
Equivalent evaporation, dry steam, from and at 212°	lb.	14975	16538	14500	13135	17037.5	14937.5	14475
Equivalent evaporation per sq. ft. H.S.	lb.	3.75	4.15	3.64	3.29	4.28	3.75	3.63
HORSE POWER								
On basis of 34.5 lb. from and at 212°	h.p.	434	479	420	380	493.5	433	419
Per cent rating developed	%	130.7	133.0	116.7	105.5	137.0	120.6	116.5
ECONOMIC RESULTS								
Actual water fed per lb. fuel as fired	lb.	5.34	6.09	6.16	6.29	6.54	6.43	6.42
Equivalent evaporation per lb. fuel as fired	lb.	6.34	6.44	6.61	6.72	7.00	6.86	6.90
Equivalent evaporation per lb. of dry fuel	lb.	6.96	6.98	7.49	7.56	7.88	7.03	7.08
Equivalent evaporation per lb. of combustible	lb.	8.72	8.10	9.10	9.36	9.38	8.59	8.71
EFFICIENCY								
Boiler	%	60.9	56.6	65.0	60.7	61.50	56.6	56.4
Combined boiler and furnace	%	58.6	55.2	61.6	58.2	60.6	54.7	52.9
METHODS OF FIRING								
Kind of firing (spreading, alternate, coking)		Spreading	Spreading	Spreading	Spreading	Spreading	Spreading	Spreading
Average thickness of fire	In.	8	8	7	9	10	9	9
Average intervals between firings	Min.	8	8	8	7½	7½	7½	7½
ANALYSIS OF FLUE GAS								
Carbon dioxide CO_2	%	7.6	7.12	7.1	8.3	9.7	8.9	10.1
Oxygen O	%	11.5	12.14	13.3	12.4	10.98	11.2	9.8
Carbon Monoxide CO	%	.25	040	.14	0	0.0	0.0	0.0
Nitrogen, etc., N (by difference)	%	80.65	80.74	80.46	79.1	79.32	79.9	79.4
Dilution coefficient		2.16	2.31	2.37	2.76	2.082	2.04	1.87

Boiler: 360 h.p. Class G-19 Stirling, 3628 sq.ft. effective heating surface.
Grates: hand-fired, herring-bone type, 83.3 sq.ft. surface.
Furnace: divided by central wall, each half having a fire arch 24 inches high above grate and 6 ft. long.
Stack: 150 ft. high above grate.

Illinois run of mine coal. Natural draft. Fires cleaned twice during each test. Average time of cleaning 25 minutes.

Coke Breeze, through 1 inch and over 3/8 inch screen. Natural draft except on No. 6. Forced draft by Argand blowers on No. 6. Fires cleaned twice during each test. Average time of cleaning 30 minutes.

BOILER TESTS.

Comparative Results with Coal and Coke Dust, using the Fuel System.

Kind of Fuel.		A Fuel Blowers, Grates and Distributors.				B Fuel Blowers and Grates, Hand Fired.						C Equipment Same as "A."
		Dust from 48 hr. Coke	Dust from 72 hr. Coke	Slack Coal Connellsville	50% 48 hr. Dust 50% Slack Coal	Coke Dust	Illinois Coal Run of Mine	50% Coke Dust 50% Slack Coal	C Coke Dust	Illinois Coal	Coke Dust	Dust (wet & fine)
Test No.		1	2	3	4	1	2	3	4	5	6	
Duration	hours	8	8	8	8	8	8	8	8	8	8	8
AVERAGE PRESSURES												
Steam at boiler by gauge	lb.	92.65	90.8	94.6	92.3	108.3	113.7	117.7	113.1	107.6	119.0	114.8
Draft in uptake	in. water					.598	.625	.645	.700	.680	.782	.75
Draft in furnace	in. water					.053	.136	.050	.057	.078	.00	.0
Blast under grate	in. water					.948	.840	.800	.783	.620	1.108	.972
AVERAGE TEMPERATURES												
Feed water entering boiler	deg.F.	54.8	55.0	52.0	60.0	80.7	79.0	79.0	76.0	74.7	76.9	67.2
Escaping gases	deg.F.	508	537	1000	627	580	580	594	638	640	601	644.2
FUEL AND ASH												
Total fuel as fired	lb.	18320	19700	17930	18708.5	19600	19892	19390	19965	19600	21750	24289
Moisture in fuel	%	0	0	2.0	1.25	7.58	9.70	10.44	12.47	15.75	8.76	18.09
Total dry fuel	lb.	18320	19700	17561.6	18512.2	18118	17412	17366	17476	16508	20040	19731
Total refuse	lb.	5972	7167.7	1804.8	4366.0	3336	3096	3428	3088	2588	4327	3941
Proportion refuse in dry fuel	%	33.65	38.33	10.27	27.50	22.1	15.5	18.6	17.7	14.3	24.7	28.08
Total combustible consumed	lb.	9138	11832.5	15757.0	13946.2	14088	14716	14138	14388	14180	16823	15770
Dry fuel consumed per hour	lb.	1697.5	2037.5	2026.9	2565.4	1802	2176	2170	2184	2063	2828	2466
Dry fuel consumed per hour per sq. ft. grate	lb.	26.6	35.7	44.7	39.4	28.9	34.9	34.7	35.0	33.1	41.7	39.5
WATER												
Total water fed to boiler	lb.	73687.5	76074.0	108272.0	61964.0	83208	105826	103115	104264	105250	105066	113461
Quality of steam	%	98.0	98.55	98.00	98.0	98.09	98.50	97.64	98.46	98.74	98.39	98.00
Total water actually evaporated, corrected	lb.	73206.9	74957.0	106196.2	60544.9	82118	104258	100680	102752	103882	104376	110212
Factor of evaporation		1.1956	1.1869	1.1969	1.1964	1.1761	1.1785	1.1769	1.1816	1.1821	1.1816	1.1816
Total equivalent evap., dry steam, from and at 212°	lb.	87571.5	89046.9	127118.0	72425.2	96563	122840	118488	121408	122816	123350	130239
Equiv. evap., dry steam from and at 212°, per hour	lb.	10946.5	11353.5	21219.2	14090.6	12072	15355	14806	15176	15277	15419	16091
Amount of steam used by blowers	%	4.71	6.38	-	-	3.14	.68	2.12	2.09	2.37	2.43	2.51
Net equivalent evaporation per hour	lb					11815	15251	14523	14859	14950	15041	14504
ECONOMIC EVAPORATION												
Water evaporated to dry steam per lb. fuel as fired	lb.	4.62	4.01	5.93	5.11	5.26	5.41	5.19	5.13	5.28	4.80	4.88
" " " " " " dry fuel	lb.	4.62	4.01	6.05	5.18	5.70	5.99	5.80	5.88	6.26	5.01	5.56
" " " " " " combustible	lb.	8.00	6.50	6.74	7.14	7.41	7.08	7.13	7.14	7.31	6.33	6.98
Net equivalent evaporation per lb. fuel as fired	lb.	5.80	4.80	7.10	6.11	6.06	6.85	5.99	5.96	6.09	5.53	5.41
" " " " " dry fuel	lb.	5.80	4.80	7.16	6.19	6.56	7.01	6.69	6.80	7.24	5.77	5.61
" " " " " combustible	lb.	9.89	7.79	8.08	8.84	8.53	8.89	8.22	8.26	8.44	7.38	8.27
COMMERCIAL RATING												
Builders' rating at 10 sq. ft. heating surface	h.p.	300	300	300	300	308	308	308	308	308	308	308
Net horse power developed	h.p.	317.3	325.4	415.1	468.4	342.5	442.1	430.7	432.8	436.0	436.0	472.7
Percent rating developed	%	105.8	108.5	138.0	156.0	111.2	143.5	134.7	139.8	140.5	141.6	153.4
EFFICIENCY												
Boiler and Furnace	%	58.85	44.77	51.79	56.94	55.78	59.36	56.61	56.94	57.40	48.69	55.45
ANALYSIS OF DRY FUEL								Coke Coal				
Volatile matter	%					2.96	35.82	2.36 35.40	3.97	31.85	3.02	1.96
Fixed carbon	%	7.82	4.97		12.34	76.30	44.44	77.23 43.48	73.93	49.73	77.38	80.76
Ash	%	54.72	50.65		55.74	20.74	19.72	20.41 20.12	20.10	18.42	19.60	17.28
B.t.u.		25.60	24.39	9.38	31.52	11415	11479	11484 10994	11388	11091	11801	12002
ANALYSIS OF REFUSE		13296	9900	12522	12515							
Combustible	%					34.27	27.67	21.25	19.86	18.96	29.20	28.99
Ash	%					65.73	68.13	78.75	80.14	85.04	70.80	71.25
ANALYSIS OF STACK GAS												
CO_2	%					9.84	8.40	8.80	7.44	7.06	8.65	13.40
CO	%					.00	.30	.05	.32	.25	.00	.25
O	%					10.36	10.30	11.70	11.92	12.04	11.42	5.35
N	%					79.80	81.00	79.85	80.24	80.72	79.95	79.30
Dilution coefficient						199	191	223	226	228	216	181
		Boiler: 300 h.p. Stirling, 3000 sq. ft. heating surface Grate: Fishole, 68.5 sq. ft. surface. Note: Steam used by blowers not deducted.				Boiler: 308 h.p., Class I-14, Stirling, 3080 sq. ft. heating surface Grate: Fishole, 42.4 sq. ft. surface.						

(To be Continued.)

Items of Interest
FROM VARIOUS LOCALITIES.

"B. T. R.," writing from Brockton, Mass., under date of the 25th ult., inclosed the following: "Close to 40 members of the Brockton Gas Light Company assembled in the Centre street office of the Company, the night of last Wednesday, the assembling being the result of a call for the organization of a gas employees' association, mainly on mutual benefit account. The call to order was made by Superintendent Henry K. Morrison, who introduced Mr. George Harris, of Albany, N. Y., whose speech was over the matter of "Gas Salesmanship." He narrated a series of general ways and means respecting how the increased use of gas appliances could be assured. His remarks so potently appealed to the thoughts of his hearers, that when he concluded he was rewarded by the adoption of a rising vote of thanks. Next in order was a discussion respecting the best ways and means of going ahead with the establishment of the Brockton Association Mr. Carroll B. Deady, of the Company's New Business Department, was elected Temporary Chairman, and those appointed to serve as the Committee on Permanent Organization (charged with drawing up by-laws and rules) were Messrs. C. B. Deady, A. W. Sides, John J. Sheehan, Eugene La Roque, Jno. Pendergast, Jas. P. Mooney, H. K. Morrison and Ed. B. Mooney. Amidst the burning up of cigars, an original poem was chanted by Carroll B. Deady. Supt. Morrison, Wm. Jodrin, Geo. Harris, E. B. Mooney and others participated in a general debate, and after adjournment the delegates adjourned to the Bristol Cafe, where, as the guests of Supt. Morrison, an informal supper was heartily enjoyed."

A HALT has been called by the proprietors of the Palo Alto (Cal.) Gas Company, who have sued out an injunction restraining the City Council from actively putting in force an ordinance requiring the Company to establish its maximum selling rate at $1.25 per 1,000 cubic feet, instead of the ruling one of $1.50. The temporary restraining order was issued by Judge Richards, of the Superior Court. The burden of the Company's prayer was that the proposed rate was confiscatory.

AT the annual meeting of the shareholders in the Bridgeport (Conn.) Gas Light Company it was agreed to issue $400,000 new capital stock, which brings the total capital to $2,000,000. The Directors re-elected were: I. De Ver Warner, F. M. Travis, C. F. Dieterich, Jas. C. Brady, N. W. Bishop, F. E. Nairn and A. E. Dieterich. The Directors subsequently re-elected the following officers: President, I. De Ver Warner; Vice-President, De Ver H. Warner; Treasurer, Geo. W. Roberts; Secretary, R. I. Munson.

THE proprietors of the Bessemer (Ala.) Gas Company have offered that property for sale to the city at an upset price of $80,000, free and clear. Under the provision of its charter the Company may not sell its rights to any intending purchaser prior to having offered it to the city at the price which proposing purchasers have offered. An offer by outsiders of the sum named led to the offer to the city. The latter has 30 days in which to accept or reject the proposition, which proposition bears date of the 14th May.

RESPONDING to the offer of a prominent citizen of St. Louis, Mo., to erect the necessary buildings, and to devote annually the sum of $1,000 for their maintenance, to be at the control and disposal of the St. Louis Society for the Prevention of Tuberculosis, the Laclede Gas Light Company has offered for such use the property owned by it in Hahn's Grove, which is eligibly located on the river Des Pines.

AT a meeting held some evenings ago, the City Council, of St. Louis, Mo., unanimously voted to rescind its action of some months ago, when it ordered the Fire Marshal to rigidly enforce the new State law directing property owners to install automatic gas cut-offs in front of their premises. The correspondent who informed us respecting this action adds: "It was originally planned that these devices were only to be installed in the instance of large buildings; but there have been amendments to the law which provide that every building entered by a service ¾-inch in diameter is compelled to have a cut off, which practically means that every small property owner in the city would have to purchase and install a cut-off, at an expense ranging between $100 and $250. The law provides for a penalty of not less than $10 and not more than $50 for every property owner who fails to comply with the law in 30 days. It then provides that if 30 days after this penalty is inflicted and no attention is paid thereto the Gas Company shall not supply the building with gas."

THE proprietors of the Worcester (Mass.) Gas Light Company have informed their customers that, beginning August 1st, the Company will bill all consumption on the continuous meter reading system or plan.

THE Citizens Electric Light Company, of Shenandoah, Pa., has been purchased by the Schuylkill (Pa.) Gas and Electric Company, which corporation is generally regarded as a subsidiary of the Harwood Electric Company, of Hazleton, Pa.

MESSRS. H. D. WALBRIDGE & CO., of this city, have purchased the properties of the Hagerstown (Md.) Light and Heat Company, and will take possession the 1st prox. Mr. Samuel B. Loose, who practically owned a controlling interest in the Company, declined to say what the purchase price was, but he insisted that the figure offered to him should be offered to every other shareholder, of whom there were 26.

THE shareholders in the Fort Plain (N. Y.) Gas, Electric Light, Heat and Power Company recently named the following Directors: J. L. Moore, A. D. Sheffield, W. E. Diefendorf, L. M. Welles and Andrew Dunn. The Directors in turn perfected the following executive management: President, A. D. Sheffield; Vice-President, W. E. Diefendorf; Secretary and Treasurer, A. Dunn.

MR. W. A. BIXBY, Manager of the Springfield (Mo.) Gas, Electric and Traction Company, continues in indifferent health. His Company has granted him an indefinite furlough, and his present purpose is to try a course of treatment, at the Mayo Sanitarium, Rochester, Minn.

THE Centralia (Ills.) Gas and Electric Company, having secured a 30-year franchise from the authorities of the outlying settlement of Sandoval, will extend its pipe and wire systems through that place.

MR. A. ASHER JONES, for some time on the staff of the Waco (Tex.) Gas Company, has been appointed to a responsible place on the force of the Hot Springs (Ark.) Company.

THE Cincinnati (O.) *Times-Star* reports that the Madisonville (O.) Water and Light plant, which the Council of that place (it is virtually a suburb of Cincinnati) decided to experiment with in a tryout of the municipal ownership scheme, was run at a loss of $1,843.01, from January 1, to May 1, according to the report submitted by Public Service Director Price, the 21st of last month. The figures further show a plant depreciation amounting to $1,163.37. During the months mentioned operating costs were $5,935.12, and the receipts $4,092.11. It is also shown that the public arc lamps (161 in number) are costing $56.01 per lamp, or $6.01 more than the contract of the Union Gas and Electric Company calls for in Cincinnati. Wherefore, Madisonville seems to be out $967.61 (counting cost of lamps and depreciation in the totals) for the period noted.

A RESOLUTION favoring the enactment of the bill which provides for the taking over of the plant of the Washington (D. C.) Gas Light Company, for operation on municipal account, was sent to the District Commissioner by Secretary John B. Colpoys, of the Central Labor Union.

"P. B.," writing from Louisville, Ky., under date of the 24th May, says that the 20-year franchise for the operation of a gas plant in Bowling Green, Ky., was sold earlier in that week to the Kentucky Public Service Company, of Philadelphia, at its bid of $201.

T. R. STRAWN is informed that the executive management of the Cincinnati (O.) Gas and Electric Company is thus composed: President, L. J. Hauck; Vice-President, S. R. Burton; Secretary and Treasurer, Norman G. Kenan; Assistant Secretary and Treasurer, Theodore Clauss.

THE Pana (Ills.) Gas Company, not being able to secure possession of the premises originally intended as office headquarters, has established itself in temporary quarters at Second street and Congress Alley.

WITH the acquiring of the Baltimore County Electric Company by the Baltimore Consolidated Gas, Electric Light and Power Company, permission to take over which property was granted some days ago by the Public Service Commission of Maryland, has gained control of all the electric plants in and around Baltimore. In fact, the only independent concern in the district is the Patapsco Electric and Power Company.

THE work of completing the placing of service pipes, in connection with the construction of the new plant at Key West, Fla., will be finished the 1st prox. At least so says Engineer-in-Chief, J. A. Mayers. "J. A. M." by the way is hoping that he soon will be coasting over the roads that are either on or adjacent of or lead to the waters of the Great South Bay, Long Island. Notably that beautiful bit of macadam that runs from Valley Stream to Long Beach.

THE proprietors of the Nashawaug (Conn.) Electric Power Company have voted to purchase a majority or all of the stock of the Peoples Light and Power Company, with the object of merging the same under the title of the Danielson and Plainfield (Conn.) Gas and Electric Company.

THE third week of May marked a very successful exhibition of the uses of gas on domestic account by the Gardner (Mass.) Gas, Fuel and Light Company. The demonstratress was Mrs. Caroline Weber, and music was furnished by the Edna Simmons Womans' Orchestra, of Boston. The attendance the opening night was well over 500, and the average for the week—the show was actually operated day and evening—was close to that figure.

IT has been definitely determined that the proposed gas plant for Petersburg, Fla., will be constructed by Mr. Roscoe Nettles, of Tampa, and his associates in the Pinellas Gas Company. Under the agreement the plant must be completed within a year, and that the maximum selling rate shall not exceed $1.75 per 1,000 cubic feet.

AT the annual meeting of the Spokane Falls (Wash.) Gas Light Company, the Trustees elected were: H. L. Doherty, F. W. Frueauff, A. B. Eilbeck, A. N. Cantril and Harry Warner; President, H. L. Doherty; First Vice-President, F. W. Frueauff; Second Vice-President, A. B. Eilbeck; Third Vice-President and Treasurer, A. N. Cantril; Secretary, Henry Warner; Assistant Secretary, C. R. Gilbert.

"DOC." BEMIS seems to have put one over his esteemed contemporary, Mr. Marks, in respect of estimating the cost of gas in Baltimore, that is to be doped out in that city, at the order of the Public Service Commission. In any event, so far the "Doc." has been retained, whereas, there is nothing doing in respect of Mister Marks.

"M. M. J.," writing from Boston, Mass., under date of the 28th ult., says: "Declaring that a municipality owning or operating a gas or electric lighting plant of its own is not amenable to an action for death through its negligence by the statutes, giving a civil remedy against 'persons or corporations' for death through negligence, the complete bench of the Supreme Court of Massachusetts yesterday set aside a verdict of $4,000 awarded to John J. O'Donnell, as administrator of the estate of his son, Thomas E. O'Donnell, against the town of North Attleboro. The deceased, with some companions, stopped at a point in Broad street, North Attleboro, the night of March 12, 1909. While leaning against a pole, his hand resting flat upon it, he sustained an electric shock of such violence that he was instantly killed. One of the defendant's wires (the town operates an electric lighting plant) had been crossed with or by another wire. The court declared that the law gives no civil remedy for the death of a human being, except as provided by statute; that the statutes giving such remedy do not especially include municipal corporations, and that the course of legislation does not permit it to hold that municipal corporations are impliedly liable under death remedy legislation. This surely looks a hardship and it is regrettable that the Attleboro authorities sought exemption on any grounds other than the one which would come through the contributory negligence of deceased. Again, Massachusetts practice in this respect differs decidedly from that governing in like instances in the States of New Hampshire, Rhode Island, New York, New Jersey, Michigan and Minnesota, in all of which communities findings in respect of like happenings, directly adverse to this Massachusetts ruling, are matters of record."

WHILE Mr. W. W. Scranton, the active head and principal owner of the properties of the Scranton (Pa.) Gas and Water Company, is not known generally as a man whose love for his fellow men is overweening, it is nevertheless a fact that he is public spirited. The latest evidence to support this theory comes from his activities in reforesting Northwestern Pennsylvania, and that in pursuance of such laudable object he has caused this spring to be set out in the district named 80,000 white pine seedlings along the Long Swamp road and about Williams Bridge dam. He has established a nursery at Elmhurst, Pa., where tree seedlings will be cultivated, the saplings to be placed at points in and about Scranton where the renewal of first growth will be most beneficial.

The Market for Gas Securities.

Consolidated, as to quotations, still sails in the region of the doldrums; that is, if doldrums is a water body, the surface of which manages to lower itself although the contributing streams are those whose currents are disposed to buoying things. The opening quotations to-day (Friday) in it are returned thus: Bid, 141; offered, 141¼. Some time, investors will awake to lost opportunities in respect of this stock.

Brooklyn Union, despite the extra 1 per cent. return for the quarter, is quoted at 143 143¼, with very little stock offering. Peoples, of Chicago, scored a further rise of 2 points in the week, the added value following comparatively large transactions in the shares. Laclede common is up 1 per cent.

Gas Stocks.

Quotations by George W. Close, Broker and Dealer in Gas Stocks.

115 BROADWAY, NEW YORK CITY.

JUNE 3.

☞ All communications will receive particular attention.

☞ The following quotations are based on the par value of $100 per share:

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked*
Consolidated Gas Co.	$78,177,000	100	141	141¼
Central Union Gas Co.—				
1st 5's, due 1972, J. & J.	3,000,000	1,000	103	105
Equitable Gas Light Co.—				
Con. 5's, due 1932, M. & S.	1,000,000	1,000	105	106
Mutual Gas Co.	3,500,000	100	165	175
New Amsterdam Gas Co.—				
1st Con. 5's, due 1948, J. & J.	11,000,000	1,000	101	102½
New York & Richmond Gas				
Co. (Staten Island)	1,500,000	100	35	50
1st Mtg Gold Bds. 5 p. ct.	1,500,000	—	98¼	100½
New York and East River—				
1st 5's, due 1944, J. & J.	3,500,000	1,000	103	105
Con. 5's, due 1945, J. & J.	1,500,000	—	95	100
Northern Union—				
1st 5's, due 1927, J. & J.	1,250,000	1,000	100	109
Standard	5,000,000	100	60	70
Preferred	5,000,000	100	90	100
1st Mtg. 5's, due 1930, M. & N.	1,500,000	1,000	103	105
The Brooklyn Union	15,000,000	1,000	143	143½
1st Con. 5's, due 1948, M. & N.	15,000,000	—	106¾	107
Yonkers	299,650	500	130	—
Out-of-Town Companies.				
Bay State	50,000,000	50	½	⅝
" Income Bonds	2,000,000	1,000	—	75
Binghampton Gas Works	450,000	100	—	—
" 1st Mtg. 5's	500,000	1,000	97	100
Boston United Gas Co.—				
1st Series S. F. Trust	7,000,000	1,000	82	85
2d " " "	3,000,000	1,000	47½	50
Buffalo City Gas Co.	5,500,000	100	5	8
Bonds, 5's	5,250,000	1,000	59	60
Capital, Sacramento	500,000	50	—	35
Bonds (6's)	150,000	1,000	—	—
Chicago Gas Co. Guaranteed				
Gold Bonds	7,650,000	1,000	104	106¼
Cincinnati Gas and Electric				
Co.	29,500,000	100	87	90
Columbus (O.) Gas Co., 1st				
Mortgage Bonds	1,500,000	1,000	96	98
Columbus (O.) Gas Lt. &				
Heating Co.	1,682,750	100	90¼	91
Preferred	3,026,500	100	75¼	80
Consumers, Toronto	2,000,000	50	200	204
Consolidated, Baltimore	13,460,064		—	—
Mortgages, 5's	3,400,000		—	—
General Mortgage 4½	10,661,000		—	—
Con. Gas Co., Baltimore				
City, 4½	2,751,000		—	—
Consolidated Gas Co. of N. J.	1,000,000	100	15	—
Con. Mtg. 5's	976,000	1,000	94	96
Bonds	75,000	—	—	100
Detroit City Gas Co.	6,580,000	—	—	50
Detroit Gas Co., 5's	381,000	1,000	75	80
" Prior Lien 5's	5,619,000	1,000	97	100½
Equitable Gas & Fuel Co.,				
Chicago, Bonds	2,000,000	1,000	—	101
Essex and Hudson Gas Co.	6,500,000	—	133	136
Fort Wayne	2,000,000	—	—	—
" Bonds	2,000,000	—	55	—
Grand Rapids Gas Light Co.,				
1st Mtg. 5's	1,350,000	1,000	100	101
Hartford	750,000	25	190	200
Hudson County Gas Co., of				
New Jersey	10,500,000	—	130	138
" Bonds, 5's	10,500,000	—	101	103
Indianapolis	2,000,000	—	—	38
" Bonds, 5's	2,650,000	—	104½	105
Jackson Gas Co.	250,000	50	82	—
" 1st Mtg. 5's	290,000	1,000	91	95
Kansas City Gas Light Co.,				
of Missouri	5,000,000	100	—	86
Bonds, 1st 5's	3,822,000	1,000	99	102
Laclede Gas Co., St. Louis.	10,000,000	100	107	107½
Preferred	2,500,000	100	114	120
Bonds	10,000,000	1,000	102½	103
Lafayette Gas Co., Ind.	1,000,000	100	—	60
Bonds	1,000,000	1,000	60	65
Louisville	2,570,000	50	143	145
Madison Gas and Electric Co.				
" 1st Mtg. 6's	400,000	1,000	106	108½
Massachusetts Gas Companies, of Boston	25,000,000	100	90	90½
Preferred	25,000,000	100	95	95¼
Montreal Gas Co., Canada	2,000,000	100	208	210
Nashville Gas Light Co.	1,000,000	100	110	—
Newark, N. J., Con. Gas Co.	6,000,000	—	97	98
Bonds, 6's	6,000,000	—	127	128
New Haven Gas Co.	5,000,000	25	182	190
Peoples Gas Lt. & Coke Co.,				
Chicago	25,000,000	100	113¼	113½
1st Mortgage	20,100,000	1,000	102	102½
2d "	2,500,000	1,000	104	—
Rochester Gas & Electric Co.	2,150,000	50	98	—
Preferred	2,150,000	50	118	—
Consolidated 5's	2,000,000	—	104½	105½
Pacific Gas and Electric Co.	15,500,000	—	67	68
St. Joseph Gas Co.—				
1st Mtg. 5's	1,000,000	1,000	96	98
St. Paul Gas Light Co.	2,500,000	100	—	—
1st Mortgages, 6's	650,000	1,000	104	105
Extension, 6's	600,000	1,000	112½	115
General Mortgage, 5's	3,447,000	1,000	94	96
Syracuse Gas Co., N. Y.	1,975,000	100	50	55
Bonds	2,047,000	1,000	101	103
Washington (D. C.) Gas Co.	1,600,000	200	450	460
1st Mortgage, 6's	600,000	—	—	—
Western Gas Co., Milwaukee	4,000,000	—	—	—
Wilmington (Del.) Gas Co.	600,000	50	—	—

MEETING TIMES OF THE VARIOUS GAS ASSOCIATIONS.

American Gas Institute.—Annual meeting, October 16 to 18, 1912. Marlborough-Blenheim Hotel, Atlantic City, N. J. Officers: President, Ira C. Copley, Aurora, Ills. Secretary, Geo. G. Ramsdell, 29 West 39th st., N. Y. City.

Canadian Gas Association.—Annual meeting and Gas Show, Toronto, Aug 26th to Sept. 7, 1912. Officers President, Arthur Hewitt, Toronto, Ont.; Secretary and Treasurer, John Keillor, Hamilton, Ont.

Empire State Gas and Electric Association.—Annual meeting, New York City, Oct. 1912. Officers: President, R. M. Searle, Rochester, N. Y.; Secretary, C. H. B. Chapin, 29 W. 39th street. New York City.

Gas Meters.—Monthly meetings. Chairman, Will W. Barnes; Commissioners, W. H Pettes, I. W. Pelly; Secretary, H Thurston Owens, 42 Pine street, New York City.

Guild of Gas Managers of New England.—Annual meeting, March, 1913. Young's Hotel, Boston; monthly meeting, second Saturday. Officers: President, Walter G. Africa, Manchester, N. H.; Secretary, H. K. Morrison, Brockton, Mass.

Illinois Gas Association.—Annual meeting, time, March 19th and 20th, 1913. Chicago, Ills. Officers: President, H. O. Channon, Quincy, Ills.; Secretary-Treasurer, Horace H. Clark, 115 No. Oak Park avenue, Oak Park, Ills.

Illuminating Engineering Society.—Annual meeting, Niagara Falls, Canada, Sept. — 1912, Meetings of Sections, monthly. Pres't, V. R. Lansingh, New York City; Secretary, Preston S. Millar, 29 W. 39th street, N. Y. City. Sections: New York, Secretary, C. L. Law, 245 West 42d street. New England, Secretary, H. C. Jones, 10 High street, Boston, Mass. Philadelphia, Secretary, L. B. Eichengreen, Broad and Arch streets. Chicago, Secretary, T. E. Aldrich, 235 Jackson Boulevard.

Indiana Gas Association.—Annual meeting, March, 1913, Indianapolis. Officers: President, Howard L. Olds, Indianapolis; Vice-President, Wm. Wallace, Lafayette; Secretary-Treasurer, Phimer Eves, Indianapolis.

Iowa District Gas Association.—Annual meeting, Burlington, Ia., May, 1913; Officers: President, C. W. Fair, Atlantic, Ia.: Secretary, G. I. Vincent, Des Moines, Ia.

Kansas Gas, Water and Electric Light Association.—Annual meeting, time, Oct. 17-19. Manhattan, Kas. Officers: President, B. F. Eyer, Manhattan, Kas.; Secretary and Treasurer, J. D. Nicholson, Newton, Kas.

Michigan Gas Association—Annual meeting, time, Sept. 4-6, 1912; Toronto, Canada. Officers: President, F. W. Blowers, Kalamazoo, Mich; Secretary-Treasurer, Glenn R. Chamberlain, Grand Rapids, Mich.

Missouri Electric Light, Gas, Water Works and Street Railway Association.—Annual meeting, April, 1913; Joplin, Mo. Officers: President, P. A Bertrand, Joplin, Mo.; Secretary and Treasurer, P. W. Markham, Brookfield, Mo.

National Commercial Gas Association.—Annual meeting and Gas Show, Dec. 2-5, 1912, Atlanta, Ga. Officers: President, C. L. Holman, St. Louis, Mo.; Secretary, Louis Stotz, 29 West 39th street, New York City.

Natural Gas Association.—Annual meeting, May, 1913. Officers: President, A. B. Macbeth, Independence, Kas.; Secretary, T. C. Jones, Delaware, O.

New England Gas Association.—Annual meeting, February,————1913 Boston. Officers: President, D. D Barnum, Worcester, Mass.; Secretary-Treasurer, N. W. Gifford, East Boston, Mass.

New Jersey State Gas Association.—Summer Meeting August 24, Atlantic City, N. J.—President, William H. Pettes, Newark, N. J.; Secretary-Treasurer, Arthur H. Osborn Belmar, N. J.

Ohio Gas Association.—Annual meeting, February ———, 1913, Columbus, O.; President, John M. Garard, Columbus, O.; Secretary, L. B. Denning, Columbus, O.

Oklahoma Gas, Electric and Railway Association.—President, Noel R. Gascho, Alva Okla.; Secretary, H. V. Bozell, Norman, Okla.

Pacific Coast Gas Association.—Annual meeting, San Diego, Cal., September 17, 18, 19, 1912. Officers: President, W. Baurhyte Los Angeles, Cal.; Vice President, Henry E. Adams, Stockton, Cal.; Secretary-Treasurer, John A. Britton, 445 Sutter street, San Francisco, Cal.

Pennsylvania Gas Association.—Annual meeting, York, Pa., April, 1913; Officers, President, H. H. Ganser, Norristown, Pa; Secretary-Treasurer, W. O Lamson, Jr., West Chester, Pa.

Society of Gas Lighting.—Annual meeting Dec., 13, 1912. monthly meetings, second Thursday. Place, New York City. Officers: President, Fred. S. Benson; Secretary, George G. Ramsdell, 29 West 39th street, New York city

Southern Gas Association.—Annual meeting, April ——— 1913, Charlotte, N. C. Officers: President, C. E. White, Montgomery, Ala.; Secretary-Treasurer, E. D. Brewer, Atlanta, Ga.

Southwestern Electrical and Gas Association.—Annual meeting, April————1913, Galveston, Tex. Officers: President, F. M. Lege, Jr., Galveston, Tex.; Secretary, H. S Cooper, Galveston, Tex.

Wisconsin Gas Association.—Annual meeting, May ——— 1913, Milwaukee, Wis. Officers: President, I. F. Wortendyke, Janesville, Wis.; Secretary-Treasurer, Henry Harmon, Milwaukee, Wis.